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A New Species of Plethodontid Salamander from the Jemez Mountains of New Mexico

By Robert C. Stebbins and William J. Riemer

TO account for the occurrence of the lungless salamander *Plethodon hardii* in the Sacramento Mountains of southern New Mexico, one may assume that the species or its predecessor arrived there via the Rocky Mountains. The country adjacent to the Rockies, except well to the north, is today, so far as is known, uninhabited by these amphibians and probably long has been unsuited to them. It seems plausible that at one time plethodontids existed across the northern part of the continent, dispersing westward from an eastern center of differentiation (Dunn, 1926: 11 and 12). From this northern reservoir one may surmise that they made their way southward, and that at some time they became widespread in the Rockies. Only two species, *Plethodon idahoensis* of the northern part of the Rocky Mountains in Idaho and *P. hardii* at the extreme southern end, have been described. It has seemed likely to us that other remnants of a once widely distributed Rocky Mountain fauna might yet exist.

On August 14, 1949, motivated by the foregoing idea, we visited the Jemez Mountains, Sandoval County, New Mexico. At the same time we wished to check on the possible occurrence of *Eurycea multiplicata* (?), reported by Dunn (1926: 316). We failed to find *Eurycea* but discovered, instead, a *Plethodon,* which we here describe. We have determined that the material, USNM 42921-2, upon which the record of *Eurycea* was based, is of this new species.

Plethodon ***neomexicanus,*** sp. nov.

Type.—Adult male, no. 49033, Museum of Vertebrate Zoology, collected by Robert C. Stebbins, August 14, 1949, 12 miles west and 4 miles south of Los Alamos, 8750 ± feet, Sandoval County, New Mexico. Seventeen paratypes, nos. 49018 to 49035, were collected. These are in the Museum of Vertebrate Zoology, nos. 49024 and 49032 as skeletons.

Description of Type (from living anesthetized animal).—*Measurements* (in mm.): snout to posterior edge of vent, 74.6; tail from posterior edge of vent to tip, 68.0; greatest width of tail, 8 mm. from its base, 5.7; greatest height of tail, at same location, 5.15; greatest width of body, at 14th costal furrow, 8.9; greatest height of body, at same location, 8.2; axilla to groin, 44.2; snout to anterior surface of forelimb at body, 18.2; snout to gular fold, 14.1; greatest width of head, 8.9; interorbital distance, 3.0; eye opening, measured from anterior to posterior eye corners, 2.3; anterior eye corner to posterior edge of nostril, 2.1; anterior eye corner to tip of snout, 3.2; fore limb, measured from juncture of limb with body to tip of longest toe, 11.8; hind limb, similarly measured, 13.2; fore foot, measured from juncture of metacarpals with carpals, 3.0; hind foot, measured from metatarsal-tarsal junction, 3.9; longest finger, measured from edge of webbing be-

tween toes, 1.8; longest toe, similarly measured, 2.6; costal grooves 18-18, counting one each in axilla and groin; costal interspaces between tips of toes of adpressed limbs, 8.

Coloration: Ground color of body above dark brown (A5 to A6[1]—Mummy Brown, Clove Brown or between the latter and Bone Brown[2]), that of head reddish brown (E6—between Vandyke Brown and Mars Brown), and that of tail light brown (between C12 and L9—between Prout's Brown and Dresden Brown); limbs colored about like body; all dorsal surfaces suffused with fine close stippling of pale yellow to cream chromatophores (1D or 1E—Light Buff to Massicot Yellow); eyelids slightly darker than rest of head due to underlying ocular pigment; iris dark brown, almost black (darker than A6—darker than Mummy Brown), marked as sketched (Plate I) with pale gold (F1 or G1—Massicot Yellow or Naphthalene Yellow); gold color occurs as tracery of fine lines that form patches of varying density above and below pupil; color superimposed on melanic background of iris but broken here and there by darkly pigmented blood vessels; gular area light buff (I6—Light Ochraceous-Buff); under side of body between limbs blue gray (A6—Deep Quaker Drab); area of body between hind limbs and posterior edge of vent, light purplish pink (A7—near Vinaceous-Fawn); under side of tail light purplish gray laterally, dull orange yellow centrally (A2 grading to I8 centrally—Wood Brown laterally, grading to Buckthorn Brown centrally) under side of fore limbs like gular area; ventral surfaces of hind limbs like pelvic area but undersides of feet slightly lighter; light-colored chromatophores of ventral surfaces cream (I2—Cream Color), scattered in irregular fashion over all ventral surfaces as isolated cells or in groups, forming blotches of varying size and variously connected; such chromatophores scarce on underside of tail and largely single and branched; underside of tail appears speckled, however, from scattering of small round ash gray to whitish glands; light-colored chromatophores more abundant in pelvic area and anteriorly, tending to be concentrated ventrolaterally except in gular area, forming pale yellow suffusion along sides of body especially between limbs, scarce in costal furrows, but forming rather continuous but irregular network in intercostal areas; concentration of pale yellow chromatophores also extending on sides of neck and on sides of tail base but rapidly weakening posteriorly on tail; numerous round pale gray to white glands scattered along sides.

General Description of Adult.—*Structure.* Average total length 116.6 mm. (11 individuals), body 58.4 mm., tail 55.6 mm. (14 individuals); slender, elongate species with short limbs and toes and with tail usually slightly shorter than body, rarely longer; costal grooves well defined with similar furrows in tail; eyes average in size for *Plethodon;* interorbital space about 1 to 1½ width of upper eyelid; horizontal dimension of eye opening contained 1 to 1½ times in snout length; head widest immediately behind eyes but little if any wider than body; well defined postorbital furrow extends from posterior eye corner to become continuous with vertical extension of gular fold on side of neck; postorbital furrow met by vertical groove behind

[1] Maerz and Paul (1930) determinations.
[2] Ridgway (1912) color names capitalized.

TABLE I

MEASUREMENTS AND COUNTS OF COSTAL GROOVES AND TEETH IN *Plethodon neomexicanus* (TYPE AND PARATYPES)

MVZ specimen no.	Sex	Snout-vent	Tail	Costal grooves (right and left)	Costal interspaces between tips of toes of adpressed limbs	Vomerine teeth (right and left)	Parasphenoid teeth (right and left)	Total number of parasphenoid teeth	Condition of gonads
Males									
49022	?	40.0	32.0	18–18	7	7–5	—	—	immature animal, sex doubtful
49023	♂	56.8	48.4	19–19	8½	7–8	65–66	131	right testis only
49026	♂	48.5	—	18–18	8	11–9	80–75	155	testes small; cloacal papillae not evident
49028	♂	54.1	57.1	18–18	7½	7–7	—	—	testes large
49029	♂	55.1	52.8	18–18	7¾	9–8	—	—	testes large
Type									
49033	♂	74.6	68.0	18–18	8	—	—	—	testes large
Females									size of largest ovum
49018	♀	58.6	54.2	18–18	8	7–7	90–90	180	1.9
49019	♀	51.0	49.0	18–18	8	7–7	—	—	.7
49020	♀	49.0	45.2	18–18	8	6–7	—	—	.6
49021	♀	57.1	59.1	18–18	8	11–9	94–92	186	1.5
49025	♀	43.8	31.9	18–18	6	8–7	58–70	128	.5 immature animal
49027	♀	58.6	55.2	19–19	8	7–7	82–82	164	1.8
49030	♀	66.1	62.5	19–19	8½	8–9	112–118	230	.9
49031	♀	58.5	—	18–18	8¼	8–7	89–87	176	1.5
49034	♀	61.6	60.0	18–18	7½	5–5	86–94	180	1.0
49035	♀	61.8	60.5	18–18	8	9–7	95–95	190	.9

mouth angle; well-defined gular fold; body oval in cross section, slightly depressed; 18–18, rarely 19 (3 of 16 animals), costal grooves, counting one each in axilla and groin; tail rounded basally, slightly depressed, vertically oval near tip; tail thickest basally, marked with furrows resembling those of body; vent simple longitudinal slit with pleated edges in both male and female; limbs relatively short, 7½ to 8½, usually 8, costal interspaces between tips of toes of adpressed limbs; toes 4–5; fore toes in order of their length 1, 4, 2, 3, hind 1, 5, 2, 4, 3 although 3 and 4 nearly identical in length; phalangeal formula of fore foot 1, 2, 3, 2 and hind 1, 2, 3, 3, 1 (sometimes 2)[8]; toes relatively short with rounded tips and with basal web; first toe of fore foot and first and fifth of hind foot much reduced; tongue oval, narrowing somewhat anteriorly, broadly filling floor of mouth, attached medially, but free all around except anteriorly, with narrow plicae diverging slightly from posterior portion; vomerine teeth usually 7–7 (range 5 to 11 per series), in two arched series separated at mid-line or rarely connected (one animal in 10 studied); parasphenoid teeth separated from vomerine teeth and arranged in single elongate oval patch, broadest posteriorly; parasphenoid patch usually shows reduction of teeth along mid-line, resulting in division, in varying degrees, into 2 patches; parasphenoid teeth averaged 172 (range 128 to 230), no sexual dimorphism in teeth evident in our material.

Color. Above brown (near Bone Brown) stippled with pale gold (Baryta Yellow) chromatophores, punctostellate in form; dorsal ground color and stippling quite uniform throughout except dorsolaterally, where ground color tends to darken slightly with golden flecks less uniformly distributed; golden flecks sometimes clumped dorsolaterally, vaguely outlining an area usually occupied by dorsal band in other species; eyelids slightly darker than rest of head, probably because of underlying dark color of eyeballs; without magnification, iris blackish with pale blue green (almost silver) patches above and below pupil; gular area and underside of tail buff cream (Drab); body sooty blue (Heliotrope-Slate) with purple patches, resulting from underlying visceral colors; underside of limbs slightly lighter than upper surfaces; ventral surfaces of feet colored about like gular area; light-colored pigment cells on lower sides of body ash gray (nearly white), sometimes with buffy cast, becoming pale gold on upper sides; melanic network tending to be reduced beneath them, forming fine stippling, spots, and blotches in gular area and on chest and abdomen (mostly lateral in position), scarce on under side of tail; upper and lower surfaces of limbs stippled with such cells, pale yellow in color.

One individual lacked light-colored chromatophores completely; even the light eye color was absent.

JUVENILE (MVZ 49022).—A juvenile specimen resembles the adult but has dorsal stripe and color of underside of tail whitish with grayish cast

[8] One phalanx in the fifth toe is evidently the predominant condition in the animals examined by us. This was determined in two animals skeletonized and in the others by attempting to bend the fifth toe, viewed under the dissecting microscope. One of 14 animals so examined exhibited a joint distal to the basal one in the fifth toe of the left foot. It is possible that other individuals may have possessed small terminal phalanges but we did not wish to dissect our paratypic series. Both specimens, USNM 42921-22, possessed a small terminal phalanx in each fifth toe; one animal, however, lacked one hind foot.

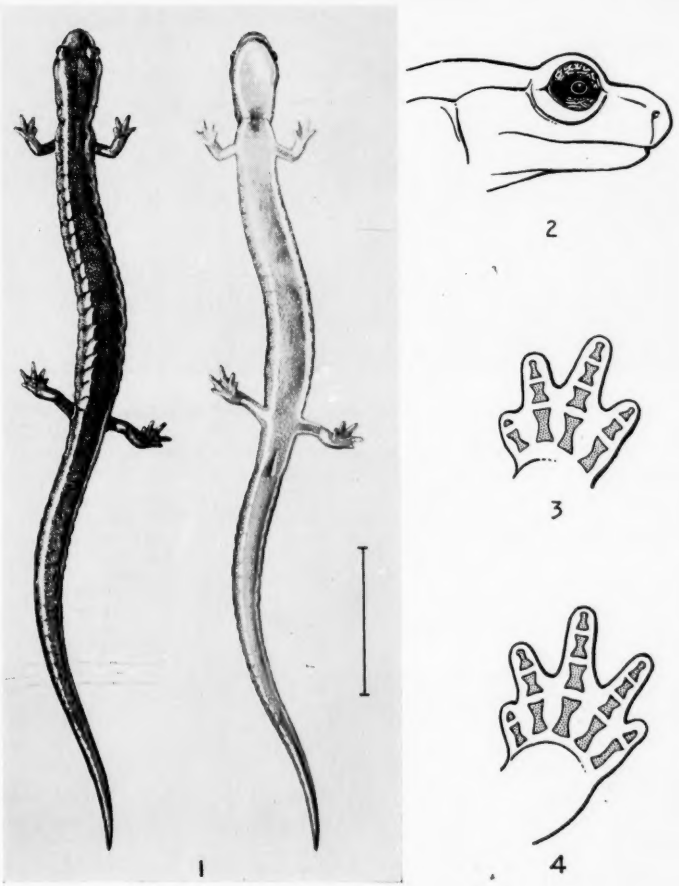

Fig. 1. Dorsal and ventral aspects of the type specimen of *Plethodon neomexicanus*, MVZ 49033, collected by R. C. Stebbins, in the Jemez Mountains, 12 miles west and 4 miles south of Los Alamos, Sandoval County, New Mexico. The illustration was made from the living animal, anesthetized in chlorotone. The vertical line equals 25 mm.

Fig. 2. Profile of the type specimen showing the distribution of light-colored ocular pigment.

Figs. 3 and 4. Right fore and hind feet respectively, in dorsal aspect, showing the skeletal elements, the phalanges and metapodials. Note the single phalanx of the fifth toe of the hind foot. The drawings were made from a cleared specimen, MVZ 49024, stained with alizarin red.

Fig. 1. The type locality of *Plethodon neomexicanus*, 12 miles west and 4 miles south of Los Alamos, 8750± feet elevation in the Jemez Mountains, Sandoval County, New Mexico. The white bark trees are aspens *(Populus tremuloides)*, the conifers are principally fir *(Pseudotsuga mucronata)* and spruce *(Picea pungens)*. The first salamander was found beneath the bark of a fir log among the conifers to the right of the middle of the picture. Others were found on a well forested slope, hidden by the trees, 100 to 200 yards from the road. The photograph was taken looking south-southeast.

Fig. 2. The habitat of *Plethodon neomexicanus* at the type locality. A salamander was obtained under the bark of the log near the large tree in the left foreground. The area was well-shaded by conifers and aspens. There was a rather sparse herbaceous growth, principally of *Oxalis*, *Fragaria*, and *Geranium eremophilium*, on the forest floor.

instead of buff cream; close, rather uniform, pale gold stippling (appearing light gray with golden tinge to unaided eye), along back from upper surface of head, including eyelids well toward tip of tail; stippling broken here and there but generally quite uniform, forming vague dorsal band. Light-colored chromatophores form coarse blotches and spots on sides—on side of head behind jaw angle, on neck, between limbs, and at base of tail; they are separated from finer speckling of dorsal stripe by a dorsolateral vague zone, where light flecks are reduced in abundance; edges of dorsal stripe vaguely indicated by a tendency toward clumping of such flecks; a few scattered light-colored pigment cells are present in gular area, mostly lateral in position, and are also present laterally on chest and abdomen, where they form pale yellow spots and blotches.

TABLE II

COMPARISON OF SPECIES OF *Plethodon** IN COSTAL GROOVE COUNT AND INTERSPACES BETWEEN TIPS OF TOES OF ADPRESSED LIMBS
[Partly from Bishop (1943)]

	costal grooves	interspaces
cinereus	17–19 (20)	6 –7
vehiculum	15–16	5 –6
yonahlossee	15 (16)	—
ouachitae	15–17	1 –3
richmondi	20–21 (23)	9 –10
vandykei	13–14	2 –3
idahoensis	13–14	2 –3
dunni	15	2½–4
glutinosus	16	1½–2½
jordani	15–16	2 –3
metcalfi	16	1 –2
elongatus	17 (18)	6 –7½
nettingi	17–19	5½–6
huldae†	18–20	7 (costal grooves)
clemsonae	15	—
wehrlei	16–17	2 –3
welleri	16	3 –4
neomexicanus	18 (19)	7½–8½

* *Plethodon hardii* has been omitted because of a question as to its generic status. The species is under study by C. Lowe, Jr.
† Recently described by Grobman (1949).

COMPARISONS.—The new species is close to *Plethodon cinereus* of eastern United States and Canada but differs in its larger size, in having a reduced fifth toe, in the constant absence in adults of a dorsal band (as based on our material) and in lacking contrasting light and dark reticulations on the ventral surface of the body.

The species resembles the Appalachian *P. richmondi* in form, but is larger, on the average has fewer costal grooves and fewer costal interspaces between the tips of the adpressed toes; it differs further in commonly having one instead of two phalanges in the fifth toe and in lacking a dorsal band in the adult.

Plethodon neomexicanus differs from *P. elongatus* of northwestern California and southwestern Oregon in having a slightly higher costal groove count,

and generally more costal interspaces between the tips of the adpressed toes; in the absence of the dorsal stripe, present in young and some adult *P. elongatus;* and in its generally lighter coloration.

From all remaining members of the genus *Plethodon* except *P. nettingi* and *P. huldae,* it differs in having more costal furrows and in having a higher costal interspace count between the tips of the adpressed toes. It differs further (including *P. nettingi* and *P. huldae*) in possessing a reduced fifth toe, and from all but *P. vandykei* and *P. idahoensis,* in having shorter toes. These characters are summarized in Table II.

Habitat

The Jemez Mountains in western north-central New Mexico lie approximately 30 miles west-northwest of Santa Fe. This essentially volcanic range rises to 11,500 feet at Santa Clara Peak, and supports heavy stands of timber and perennial streams. The body of the range forms an island of Transition-Canadian Life-zone rising out of an Upper Sonoran plain. However, this island is not well separated from similar mountain groups to the north and east. It is essentially the southwestern corner of the main mass of the Rocky Mountains of Colorado.

According to Bailey (1913), the Transition Zone in New Mexico occurs between 7000 and 9500 feet elevation; the Canadian occurs from 8500 to 12,000 feet. The Transition Zone, 10,000 square miles in extent, occurs in the southern portion of the state only as small scattered islands and is characterized by Bailey as being extremely uniform in climate, fauna and flora throughout New Mexico. Furthermore, even the isolated southern mountain regions contain few species which are not common to the main mass of the Rockies. Presumably the same is true of the 2000 square miles of Canadian Zone, which is largely confined to the northern part of the state. Of the Jemez range, Bailey specifically states: "The plant and animal life is mainly that of the southern Colorado mountains . . . "

Because of the scattered nature of these mountain areas and the manner in which they rise out of the arid and relatively level Upper Sonoran plains, Bailey feels they are able to precipitate the maximum amount of rain and snow. Heavy snows occur in winter; some banks often last into late spring in the Canadian Zone. During mid-summer there are frequent, often daily, showers of rain or hail.

August 14, 1949. The type locality, 12 miles west and 4 miles south of Los Alamos, 8750 feet, Sandoval County, New Mexico, is an area with a slight to moderate (10° to 35°) slope facing west to northwest and is covered with a good stand of timber; it is 150 yards from a large open meadow used as summer range for sheep. No stream and almost no exposed rocks are in the immediate vicinity.

At the collection site the principal trees are *Abies concolor, Acer glabrum neomexicanum, Picea pungens, Populus tremuloides* and *Pseudotsuga mucronata* of which *Pseudotsuga* is by far the most abundant. Beneath the trees an understory of herbaceous plants, 2 to 6 inches high and uniformly spaced, provides a rather continuous cover over the ground. Occasional shrubs rise

to 1½ feet. Grass in thin, small clumps rises to 18 inches in the level areas where herbaceous plants are shorter and more sparsely distributed. The smaller plants associated with the salamanders include: *Actaea viridiflora, Artemisia franserioides, Fragaria mexicana, Galium* sp., *Geranium eremophilium, Osmorrhiza obtusa, Oxalis metcalfei, Rubus parviflorus, Salix* sp., *Thalictrum cheilanthoides, Trautvetteri grandis* (*?*), *Trisetum montanum, Vaccinium scoparium* and *Viola* sp.

A 1½-inch mat of dead needles and leaves, sooty brown in color, covers the soil. This mat is made up mostly of *Pseudotsuga* needles but the leaves of the broad leafed plants are most conspicuous. Rotting and rotted logs are abundant, particularly on the sloping ground. The majority of such logs are well rotted throughout, saturated with water and covered with lichens and mosses. It is in association with such logs, especially those of the *Pseudotsuga,* that the salamanders are found. They were taken under the bark, in fissures in the center of decomposed logs and also beneath logs where the salamanders were in contact with the soil.

The following animals were observed to share the logs with the salamanders: centipedes (several kinds, all small), spiders, earthworms, camel crickets, carabid beetles, wire worms and snails. The less well-rotted logs often housed ant colonies—such logs did not yield salamanders.

Search for specimens was made in spots other than the type locality but no salamanders were found. Hence, it is not known whether the animal occurs at higher or lower elevations, whether it is restricted to the relatively shaded northwest facing slope or whether it prefers forests predominently of *Pseudotsuga.*

The following is a description of a typical collection site based on field notes of the authors.

Time, 5:15 P.M. An adult taken in the middle of a log which is 6 inches in diameter, 7 feet long and well covered with mosses. Water is easily squeezed from the decayed wood. Leaf litter is thick and dry on top but wet just beneath the surface. Slope, 30° to NNW. Site, 40 feet upslope from previous capture. *Acer* and *Pseudotsuga* overhead, the herbaceous cover thick, 4 inches high. This spot is most shaded of any so far, with a canopy of 60-70 per cent; reduced when maples lose their leaves. When first exposed the animal started quickly down a crevice in the rotten wood. Camel crickets and carabid beetles present. Temperature of wood where salamander taken 12.8° C, surface of leaf mat 14.8° C, air 3 inches above log 16.2° C. Clouds breaking up after releasing only a few small drops.

All of the 18 specimens taken at the type locality were captured within an area of 75 by 200 yards. Considerable time was spent searching in an ideal-looking, but slightly drier, area immediately adjacent to the type locality, but no salamanders were found. Charles Lowe, Jr. visited the type locality on August 30. He searched for 3 hours but found no salamanders. He reported conditions too dry.

In view of the snow blanket in the winter and the rains in the summer it is supposed that this species is active on the surface during the summer months. In this respect it would be more like the eastern plethodontids in habit than the western forms.

Acknowledgments

The discovery of *Plethodon neomexicanus* was made possible by support from the John Simon Guggenheim Memorial Foundation, and occurred during the progress of field work on the herpetofauna of western North America, sponsored by the Foundation. The senior author wishes to express thanks for this aid.

The staff of the herbarium of the University of California identified the plants procured at the type locality.

Drs. Remington Kellogg and Doris Cochran of the United States National Museum generously allowed us to examine the specimens upon which the record for *Eurycea* in the Jemez Mountains was based.

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A New Toad from Mexico with a Redefinition of the *cristatus* Group[1]

By I. Lester Firschein

In August, 1947, I spent a week making a preliminary investigation of the isolated volcanic Los Tuxtlas region in east-central Veracruz, Mexico, and obtained a small series of a high-crested toad related to *Bufo cristatus* Wiegmann.

The range known as Los Tuxtlas consists of a series of five major cones representing the eastern base of a transverse zone of fracture and volcanic action across Mexico, along the 19th parallel. The highest, Volcán San Martín, rises to about 6,000 feet. These mountains lie in the Humid Division of the Tropical Zone and are surrounded by the savannas of the Arid Division. Thus extensive savanna plains, especially to the south and the west, limit the spread and condition the development of the endemic fauna of the region. The area falls within the Southwestern Lowland Temperature Province of Page, which has an average maximum temperature of 92°-98° and a minimum of 58° to 68° F. The relative humidity of this Province is the highest of any in Mexico. Rainfall occurs throughout the year (Middle Gulf Coast Rainfall Province of Page) but the periodicity of the rainfall is well marked. The rainy season begins late in May and is over by October, with September and June as the months of heaviest rains.

This east-central Veracruz area supports the most northern neotropical faunal elements (Hoogstraal) and because of the interdigitation of the semi-arid scrub forest and humid condition, the nearctic fauna can also survive here. However, there is still a third and more isolated fauna of this region—a relict population occupying the higher mountain slopes.

This is true in spite of the fact that in modern times, in 1662 and again in 1793, Volcán San Martín underwent eruptions. The lava flows covered the north slopes and base of the volcano while great ash drifts were deposited on the south and west slopes.

When I ascended this volcano from the south, the lower approach was made, in the company of Indian guides, through the typical tropical Rain Forests that matted the lower slopes. The humid hot forest had a high canopy, overgrown with a profusion of lianas and epiphytic Bromeliaceae. This forest grew on the fertile, decomposing volcanic ash, with little undergrowth present. A little higher, on the southwest slope, the overhead canopy was broken at intervals by small clearings occupying bare areas of volcanic ash drifts. About 600 or 700 feet below the crater rim the forest thinned out and the trees were decidedly stunted. At this level, wrapped in the mists that more or less continuously overhang the volcano, several examples of the new toad were collected as they were hopping on the ground (10 A.M.). None were discovered on the rim of the crater, which had fractured from the terrific explosions into several peaks, the highest one of which was ascended.

[1] Contribution from the Museum of Natural History and Department of Zoology of the University of Illinois, Urbana.

The highest slopes of the range are buffeted by winds from the north and northeast. During my trip the temperature at the highest point registered 50° F. or a little above. As Wetmore (1943: 223) points out, the higher slopes belong to the Subtropical Life Zone, which is maintained at this relatively low altitude (down to 3,000 ft.) considering the latitude of the region, by the presence of the cloud banks that cloak the upper reaches of the mountain peaks and help maintain a much reduced temperature. The new toad should be considered (like Wetmore's new endemic bird species, with subtropical affinities, from the same area) to be a fragment of the fauna represented during the Pleistocene, and maintained here, in isolation, because of the lowered temperature and the surrounding lowlands. It is noteworthy that *Bufo cristatus* occupies the same zone near Jalapa.

The *Bufo cristatus* Complex

Since 1883, when Wiegmann described *Bufo cristatus* and *B. valliceps* from Mexico, these forms, together with *Bufo occipitalis* Camerano (1879), or the groups to which they belong, have been hopelessly confused and synonymized in literature.

Peters (1863) cites the 2 cotypes of *cristatus* in the Berlin Museum, and Cope (1866) reports the species as part of the Sumichrast collection from Orizaba and also of the collection of Sartorius from Veracruz. Brocchi (1881-1883) synonymizes *cristatus* with *valliceps*. Sumichrast (1882) recognizes the validity of *cristatus* and records it (probably incorrectly) from localities in Veracruz (Orizaba, Córdoba, Huatusco). Boulenger (1882: 281) mentions *cristatus* in name only. He does not recognize it nor does he place it in synonymy. He includes, however, a description of *Bufo occipitalis*. Garman (1884) also names *Bufo occipitalis* but makes no mention of *cristatus*.

Cope (1887) gives localities for both *valliceps* and *cristatus* but differentiates the two forms only by name. It is questionable if Cope actually realized what *cristatus* was. He had not seen the types, and from Wiegmann's original description it would be difficult to visualize the characteristics of this form as opposed to *valliceps*. However, he does record a specimen from Jalapa, the type locality of *cristatus*.

Günther (1901: 250, Tab. LXIX, fig. C) synonymizes *cristatus* with *valliceps* and also recognizes *Bufo occipitalis*. Therein are listed the characters (from the actual type) of this form, supposedly from Mexico. The figure and description, however, compare favorably in all respects with *cristatus*.

Kellogg (1932) rightfully synonymizes *occipitalis* with *cristatus*, evidently basing his opinion on Günther's illustration and description, supplied by Camerano. He correctly diagnoses *cristatus* and had examined and tabulated the characters of the Berlin types.

Taylor and Smith (1945: 559, pl. 23, figs. 5, 6) give several localities where they obtained a form that they identified as *Bufo cristatus*. They remark that this form was not at all rare around the region of Cuautlapan and was found in the same pools where they obtained *Bufo valliceps*. In this paper *cristatus* was not redescribed nor compared with Kellogg's figure or description. *B. cristatus, sensu* Taylor and Smith, has been reported in later

papers by Smith (1946) from Ocozocoautla, Chiapas, and (1947) from San Lorenzo, Veracruz. In his 1947 paper Smith compares *cristatus* and *valliceps*.

Large series of *Bufo cristatus, sensu* Taylor and Smith, have been examined (from all localities listed by Smith and Taylor in the Mexican Amphibian Check-list, 1948). When compared with true *Bufo cristatus* these toads were found to be quite unrelated, apparently representing 2 undescribed species (a lowland and a highland form) closely allied to *Bufo valliceps*.

Considering the confused history of these names it is apparent that *Bufo cristatus (sensu strictu)* must be differentiated anew from *Bufo valliceps*. The two groups may be defined as follows:

Bufo cristatus GROUP.—Large Mexican toads with exceedingly swollen parietal crests as high as or higher than the other cranial crests. Postorbital crests greatly thickened when merged with the parietal crests, or absent. Pretympanic crests absent, or if present only one-third the length of the supratympanic crests. Tympanum small and indistinct, or large and with borders well evident, always more than its diameter distant from eye. Referred species: *cristatus* and *cavifrons*, sp. nov.

Bufo valliceps GROUP.—Large toads with high parietal crests but never higher than the other cranial crests, usually not noticeably swollen. Postorbital crests always present but never thickened. Pretympanic crests usually present and about as long as supratympanic crests. Tympanum large, distinctly outlined and always less than its diameter distant from the eye. Referred species: *valliceps, cristatus (sensu* Taylor and Smith, *et al)*.

Bufo cristatus is known definitely from the following individuals: the 2 Wiegmann cotypes, Nos. 3523–3524 from Jalapa, Veracruz, at the Zoologisches Museum, Berlin;[2] No. 1869–1–6, Naturhistorische Museum, Vienna, with no locality data; the type of *Bufo occipitalis* Camerano, in the Zoological Museum at Turin, Italy, supposedly from Mexico (this specimen could not be located at the time of Kellogg's visit to the Museum in 1930); No. 8362, Museum of Comparative Zoology, collected by Dunn in 1921 at Jalapa, Veracruz.

Kellogg (1932: 33) redefines the species from Dunn's specimen, but in order to differentiate *cristatus* from the new species it is necessary to restate some of the more salient features in more comparative terms. The following description is also based on Dunn's specimen and figures 1 and 2 represent Wiegmann's cotype, No. 3524.

Bufo cristatus may be characterized as follows: parietal crest not noticeably elevated over other cranial crests, swollen and thickened, laterally merging with postorbital crests; a very short supratympanic crest; canthal crest low, not elevated, and sloping gently toward snout; little trace of a preorbital crest, but area of crest slightly marked by raised tubercles; no wide flat shelf present above tympanum and behind eye; tympanum bordered superiorly by parotoid gland; parotoid large, rounded, long and almond-shaped; tympanic area small, borders indistinct; no pretympanic crest. First and

[2] No. 3524 Zoologisches Museum, is designated herewith as the lectotype of *Bufo cristatus* Wiegmann.

second fingers sub-equal. Upper jaw with a black stripe at eye level and also barred anteriorly near nares; interorbital black stripe not extending onto upper eyelid; faint indication of a narrow light median dorsal stripe, not bounded anteriorly by a black triangle; lateral area of body darker than dorsum; tympanic area not especially darker than head; belly mottled; throat and upper ventral surface of femur pigmented.

A second and only other known member of the *cristatus* group is the species obtained on Volcán San Martiń. It may be known as:

Bufo cavifrons, sp. nov.
Plate I, Figures 3, 4

TYPE.—Univ. Ill. Mus. Nat. Hist. No. 8741, an adult female. Collected August 29, 1947, 500 feet below peak of Volcán San Martín, San Andrés Tuxtla, Veracruz, by I. Lester Firschein.

PARATYPES.—A small series is represented in the private collection of M. Maldonado-Koerdell, Mexico, D. F.

DIAGNOSIS.—A large toad related to *Bufo cristatus* Wiegmann, with high, swollen parietal crests that do not extend onto postorbital region. Tympanum large, distinct; first finger longer by a third of its length than the second; a well-defined preorbital crest. A deep cavity present on dorsal surface of head, flanked laterally by canthal, frontal and parietal crests which rise at their highest point some 6 mm. above the floor of the depression.

DESCRIPTION OF TYPE.—Adult female, with a snout to vent length of 88.2 mm. Parietal crests swollen, elevated above supraorbital crests, not thickened laterally so as to form a postorbital extension; instead, a bony, flat shelf in postorbital region, bounded by outer edge of parietal crest, parotoid gland, and laterally by a relatively long supratympanic crest projecting as a shelf over tympanic region and completely excluding the parotoid from the tympanum; anterior edge of parotoid at about the posterior tympanic margin; a short pretympanic crest present, less than one-third length of supratympanic crest; a well defined, elevated preorbital crest; parotoids small, not rounded, outer edge straight, anterior area square, forming an apex posteriorly; tympanum large, distinct, its border indicated by a raised margin, separated by more than its length from posterior corner of eye; canthal crest elevated and sloping sharply toward snout; snout short, very blunt. First finger longer than second; distal subarticular tubercle on third finger double; toes two-thirds webbed, with heavy lateral fringes especially evident on 4th toe; last three phalanges of 4th toe free of webbing; distal subarticular tubercle of 4th toe single; subarticular tubercles of toes rounded and elevated; many supernumerary tubercles on plantar surface; inner metatarsal tubercle salient, elongated and elevated; outer tubercle round, two-thirds size of inner; a slight elevation of tubercles along tarsal fold region. An enlarged lateral series of tubercles extending from posterior apex of parotoid to inguinal region; dorsal surface of skin smoother than in any other crested *Bufo* known from Mexico; small, flat, non-pustulate tubercles irregularly and sparsely distributed over dorsum; sides and venter granular.

In coloration, this toad is also quite distinctive. There are no pattern markings on the dorsal surface as are usually present in *valliceps* and its

Figs. 1-2, *Bufo cristatus* Wiegmann, lectotype, Zool. Mus. Berlin No. 3524, Jalapa, Veracruz. Snout-to-vent length, 75 mm.

Figs. 3–4, *Bufo cavifrons*, n. sp. Type, UIMNH. No. 8741, Volcán San Martín, San Andrés Tuxtla, Veracruz. Mexico.

derivatives. Instead there is simply a bilateral arrangement of color in longitudinal areas on either side of a median dorsal light stripe. The immediate area lateral to the dorsal stripe is brown. Lateral to this is a light gray band sharply bounding the dorsolateral area by its inferior margin, which is formed by a row of enlarged tubercles. The area below this line is dark brown, of the same width as the light gray and dorsal brown bands. No interorbital black line present, but rather a black stripe between the parietal crests. A black triangle is formed with the interparietal stripe forming the base, the apex meeting, dorsomedially, the two broad black bands that border the anterior median stripe margins.

The parotoid gland is bicolored; its superior surface is light gray with a slight indication of some black maculation; the inferior surface and area below are dark brown. The tympanic area, from the supratympanic shelf to the border of the upper jaw, is dark brown, with a black band immediately above the jaw commissure. There is no barring on the upper jaw margin. The pectoral region is mottled, the posterior venter and throat very lightly so; the upper surface of femur is white. There is a single broad dark band on femur, with one dark band on the tibia and a dark band on the tarsus that extends in a straight line when legs are folded. One dark band is present on superior surface of metatarsal.

Measurements in mm.: (the figures in parenthesis represent the measurements of *Bufo cristatus* MCZ No. 8362, a female, filled with eggs at about the stage of maturity). Body length 88.2 (47.2); head length 29.5 (15.7); supratympanic crest length 8.8 (1.9); length of upper eyelid 10.6 (6.0); width of upper eyelid 7.4 (4.1); interorbital width 12.4 (6.1); interparietal space 8.0 (4.0) parietal crest width 5.9 (3.1); eye to snout length 11.4 (7.0); eye to tympanum 5.7 (2.5) tympanum diameter 5.0 (1.8); paratoid length 12.0 (9.7); paratoid width 6.0 (5.3); head width at tympanum level 37.0 (17.4).

REMARKS.—The relationships of the *cristatus* group remain obscure. Certainly it is not, as has been thought, closely related to *Bufo valliceps*. Although the basic crest development and color pattern resemble a somewhat generalized conception of the *valliceps* group, there are many differences of diagnostic nature indicating that the groups are remote. There is some evidence, however, that both groups separated early from a common stock.

ACKNOWLEDGMENTS

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Rhythmic Color Change in the Lizard *Xantusia vigilis*

By HERBERT H. CASWELL, JR.[1]

WHEN investigating color changes as controlled by temperature and light in desert lizards of southern California, Atsatt (1939) discovered that the Xantusiidae showed a response to these factors markedly different from that of the Iguanidae and Gekkonidae. In addition, the action of environmental factors in this group was obscured by an unusual amount of variation in response from individual to individual and from time to time in the same individual. Atsatt postulated a response to excitement and also a possible daily color change cycle. Excitement caused by rough handling, the presence of other lizards, contact between lizards, or activity in food getting was, in her experiments, often followed by a change to the light phase.

Further observations on *Xantusia vigilis* by myself confirm the fact that excitement does produce a color change, but indicate that the change is not invariably to a lighter phase. This color change can and does take place in the brief time required for recording an observation. Because of this it became evident that an investigation of these individual responses, especially if any rhythmic factor were involved, would require a more refined method than visual observation. Since color change occurred so rapidly, a method of recording all subjects simultaneously was needed. Moreover, since the change is a graded reaction rather than an all-or-none response, a method that would give a quantitative, non-subjective, measure of degree of darkness was indicated.

Preliminary observations made on a series of 10 lizards that had been kept in captivity on a diet of meal worms, from May 21, 1949, to August 3, 1949, revealed some pertinent facts. Generally speaking these observations were consistent with Atsatt's findings. Contrary, however, to her report, these lizards were not all dark when caught. All those collected in late evening from the Joshua-Larea community near Palmdale were light, while those from the Joshua-juniper community near the San Gabriel Mountains

[1] The author wishes to express his appreciation to Dr. R. B. Cowles for his suggestions and criticism and to Dr. S. R. Atsatt for access to her original notes.

were all dark when collected early the next morning. At this time the evening group was still light by comparison. The two groups maintained their difference in color until they had been brought into the laboratory. The possibility that the two populations had different inherent color responses was quickly ruled out. When both were kept under identical conditions no significant difference in response was observed. The hypothesis that the lizards responded by color change to contact, or shelter, or both, was eliminated, for no such response could be elicited. Rapid color change, both darkening and lightening, was obtained by introducing an alligator lizard, *Gerrhonotus multicarinatus,* with taped mouth, into the cage with the xantusias, thus confirming the fact that emotional factors could induce change without any change in the physical environment. Whether or not a rhythmic change in color took place under constant environmental conditions remained to be demonstrated.

Methods of Experimentation

To satisfy the requirements of quantitative, instantaneous recording of pigmentation, a photographic method was decided on. A board was prepared with 3 columns of 4 individual celluloid compartments, the columns lettered and rows numbered, with a gray step scale fastened along one side. This gray scale, divided into 19 steps from white to black, was recorded on each negative along with the images of the lizards. The degree of darkness of the lizards was determined by comparing the density of their image with the density of the steps on the gray scale, using a transmission densitometer. This method eliminated errors that might otherwise have been introduced by slight differences in exposure or development of the films, and obviated the necessity of a subjective judgment of darkness of either the lizard or its photographic image. Exposures were made by electronic flash tube ("Strobe") light with a duration of one five-thousandth of a second. The assumption is made that flashes of this brief duration could not have influenced the color of the lizards. Panchromatic film was used.

Twenty-two lizards were used as subjects. All were caught in the Mohave desert in the Palmdale-Victorville area. These were placed in a darkroom where light, temperature, and humidity were constant within narrow limits. After an acclimatization in total darkness, for a period of four hours in the first experiment, and eighteen hours in the second, a series of 24 photographs was made. The procedure in both experiments was the same. The camera and flash tube were set up above the test board and the darkroom lights turned off. The lizards were then left alone for the acclimatization and disturbed thereafter only by actual picture taking. In the completely darkened room the flash apparatus was switched on and when the condensers were charged, the camera shutter was opened, the flash discharged and the shutter closed. A flashlight shielded so that it produced only a tiny, dim beam of light was then used to advance the film. Care was taken not to shine even this dim light directly on the test board. The whole procedure took only about forty seconds. My preliminary work and the results of Atsatt's experiments had indicated that the evening hours were most critical, thus pictures were taken at one-hour intervals during this time, and at two-

hour intervals during the rest of the day. The twenty-four hour time scale is used for the figures.

The 12 subjects for the second experiment were caught in the Palmdale area the evening of August 9, 1949, and placed one per compartment in the test board early August 10. Six of these lizards were pregnant females. After acclimatization a twenty-four hour series of photographs was made. The temperature and humidity in the darkroom were checked during this experiment by a recording Hygrothermograph. The temperature proved to be constant within 1.5° F and the humidity within 4 per cent, except for the last two hours of the experiment, when it varied an additional 4 per cent coincident with a sudden weather change.

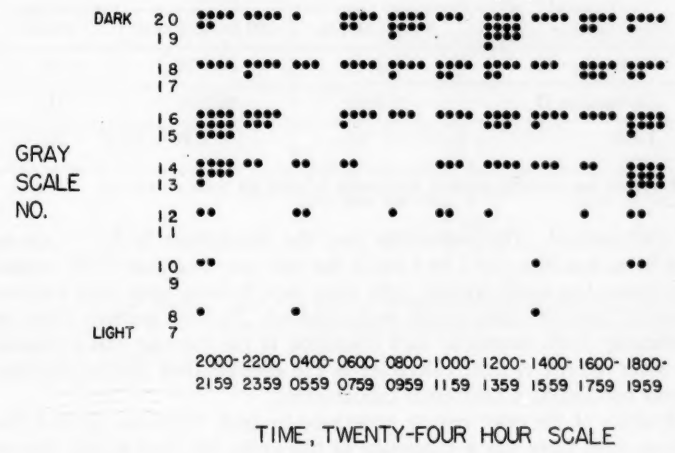

Fig. 1 Scatter diagram showing darkness in terms of standard gray scale readings plotted against time of observation.

Times given in this figure are based on the system of a 24-hour clock. The conversion to ordinary time system is as follows: 0001–1159 = 12:01–11:59 A.M.; 1201–2359 = 12:01–11:59 P.M.

Results

The two experiments showed essentially the same pattern of response by the animals. The first group, however, which had been subject to the preliminary observations, showed instances of more extreme paling than did the second group. The groupings of the two sets of data when degree of darkness was plotted against time of observation were substantially the same, nor did the pregnant females differ as a group in this respect from the rest of the animals. Hence in the discussion which follows all observations are lumped together, giving a total of 221 separate items of data (Fig. 1).

Examination of the raw data showed some indication of a rhythm in coloration, more individuals apparently tending to be darker during the morning and early afternoon hours, and more tending to be lighter during

evening and early night hours. The highest frequency of light coloration is found at about 7:00 P.M. Interestingly, at this season sunset time is about 6:50 P.M. By assembling the data into two time groups, one corresponding to daytime hours, the other to the evening hours, and into two degree-of-darkness groups divided between numbers 16 and 17 on the gray scale, it is possible to make a contingency table (Table I) and test for association by

TABLE I

CONTINGENCY TABLE OF DEGREE OF DARKNESS AND TIME OF OBSERVATION, *Xantusia vigilis* UNDER UNIFORM CONDITIONS OF LIGHT, TEMPERATURE AND HUMIDITY

Degree of darkness	Time		
	6:00–11:59 P.M.	4:00 A.M.–5:59 P.M.	Totals
Darker than 16	43.5/30	62.5/76	106
Lighter than 17	47.5/61	67.5/54	115
Totals	91	130	221

Theoretical frequencies for complete independence in upper left corner of each cell.
$Chi^2 = 13.62$. P much less than 0.01.

the Chi^2 method. The probability that the distribution is due to chance alone is far less than 0.01. As a check the data were analysed in the original time groups but again dividing light from dark between gray scale numbers 16 and 17, and the same results were obtained. By both methods there are significantly more records of dark coloration in the morning and afternoon, and more records of light coloration in the evening than can be explained without postulating a daily color change cycle.

Analysis of the color change undergone by each individual showed that in most cases there was a suggestion of this cycle, but that at any time of the day the animal could change from one extreme to the other between successive records. The commonest type of color change consists of frequent and rather wide fluctuations between dark and light. Examination of Figure 1 shows that at all times of day both very light and very dark individuals are present, though this does not obscure the basic pattern. It does emphasize, however, the extremely individual nature of color change in this species, and that the color change mechanism must be controlled to a great extent by internal factors acting independently of the external environment. This would explain the anomalous results obtained by previous experimenters.

At 12:30 P.M., fifteen minutes after the room lights had been switched on at the conclusion of the second experiment, a check series of photographs was begun, and continued until 3:30 P.M. The effect of this sudden transfer from total darkness to light at a time of day when the lizards are normally darkest is shown in Figure 2. There was a sudden increase in the number of light individuals followed apparently by a gradual swing back toward the typical distribution. The change from darkness to light probably resulted in a drastic upset of emotional balance resulting in pronounced color change, which returned to normal as adjustment followed. This part of the

experiment is suggestive rather than conclusive, and is included only as it bears on the central problem of variability in coloration.

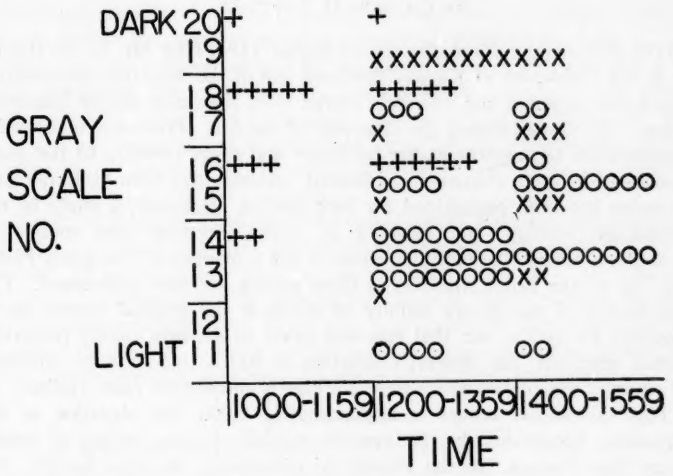

Fig. 2. Scatter diagram illustrating effect of sudden illumination on dark conditioned *Xantusia vigilis*. For conversion of times listed in this figure see caption to Fig. 1.

+, records in continuous darkness just before lights on;
o, records immediately after lights were turned on;
x, records of same time as above but for preceding day in darkness.

Conclusions

There is a daily color change cycle in *Xantusia vigilis* that operates independently of color changes resulting as responses to emotional and environmental factors.

Dark coloration is normally present from early morning to late afternoon, followed by lightened coloration in the evening. The lizards are palest at about 7:00 P.M., darkening somewhat thereafter.

Sudden changes in environment cause marked deviation from the condition normal at the time of day in question.

Individual variability in this species is so great that it usually masks the regularity in color response made apparent by statistical analysis.

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The Systematic Status of the Salamander *Plethodon hardii*, with a Discussion of Biogeographical Problems in *Aneides*

By Charles H. Lowe, Jr.

THE discovery of *Plethodon hardii* Taylor (1941) by Mr. D. E. Hardy, of the University of Kansas, disclosed one of the only two plethodontid salamanders reported and definitely known from the entire Rocky Mountain system.[1] It followed closely the discovery of the first (*Plethodon idahoensis*) approximately ten months earlier by Slater and Slipp (1940). In the years subsequent to their discovery, additional material has been collected and *Plethodon* has been maintained for both species. However, a study of the morphology, ecology, and behavior of adults, juveniles and encapsuled larvae has disclosed the fact that *hardii* is not a member of the genus *Plethodon* but of the genus *Aneides*, as these genera are now understood. The misjudgment of the generic affinity of *hardii* in the original description is accounted for by the fact that this was based on a single, poorly preserved juvenile specimen, the skeletal characters of which could not be analyzed and external features of which were not clearly discernible (*fide* Taylor).

This salamander occurs at approximately 9,000 feet elevation in the Sacramento Mountains, in the summer rainfall climatic regime of south-central New Mexico. In the vicinity of Cloudcroft, the type locality, the species inhabits a predominantly Douglas fir (*Pseudotsuga taxifolia*) habitat.[2] The general environmental aspect is strikingly similar to that of the northern California and Oregon coast Douglas fir forests where members of *Aneides* as well as other plethodontid genera, including *Plethodon*, occur. The other known Rocky Mountain plethodontid salamander, *P. idahoensis*, lives considerably farther north and at a lower elevation (2,160 ft.). While collecting *idahoensis* at the type locality (the only known locality), Coeur d' Alene Lake, Kootenai County, northwestern Idaho, it was noted that the habitat there is not unlike that of *hardii* at higher elevation in New Mexico. Concerning the habitat of *idahoensis*, Slater and Slipp (1940) state: "The forest in this vicinity has a humid aspect, containing much douglas fir and dwarf maple, while a few miles westward the yellow pine and the open plains of the arid transition predominate."

In August, 1947, I attempted to collect *hardii* in the vicinity of Cloudcroft, but was unsuccessful. In August, 1948, Messrs. K. S. Norris and R. G. Zweifel of Los Angeles, attempted to collect it at Cloudcroft, but were also unsuccessful although conditions seemed proper. In August, 1949, we attempted a third time in the same general vicinity and were successful. Norris and I collected good series of both young and adults and a cluster of 3 eggs in an advanced stage of development. At approximately the same time, R. C. Stebbins and W. J. Riemer, of Berkeley, in a different party, also collected some individuals of *hardii* in the vicinity of Cloudcroft.

[1] A new plethodontid species from the Jemez Mountains, northern New Mexico (old locality record for *Eurycea multiplicata*, is described in this issue of Copeia by R. C. Stebbins and W. J. Riemer.

[2] Taylor (1941) states that the type specimen of *P. hardii* "was found under the bark of a rotten pine log, in heavy pine forest." As it was collected at approximately 9,000 ft. at Cloudcroft, it may actually have been found under the the bark of a rotten Douglas fir log, in heavy Douglas fir forest.

Upon seeing the living animal, and in its natural environment, one is struck with the overall *Aneides*-like aspect of the salamander as well as the similar habitat. By breaking apart large, rotting, Douglas fir "home logs," like those inhabited by *Aneides ferreus,* we found the cluster of pediceled eggs (containing larvae), the presence of which was suspected. With the clue provided by observation of the external morphology, behavior and ecology of adults, juveniles and of the eggs, all resembling *Aneides* rather than *Plethodon,* the study of additional pertinent aspects of the general morphology of *hardii* was undertaken. The results of the study are given here and will be presented in more detail elsewhere in a monograph in preparation on the general and physiological ecology, systematics and evolution of the members of the genus *Aneides.*

Intact skeletons of *Plethodon idahoensis, dunni, elongatus* and *vehiculum,* and *Aneides aeneus, ferreus, flavipunctatus, lugubris* and *hardii,* have been studied. In preparation of skeletal material, a modification of the potassium hydroxide-hydrogen peroxide clearing and Alizarin Red S staining technique for bone has been employed. From 2 to 7 specimens of each form have been prepared for skeletal analysis. Ample material, alive as well as preserved, of all of these forms has been used for the study of other characters.

Comparisons

Plethodon idahoensis is markedly different from *A. hardii* and it is unquestionably a *Plethodon,* as the genus is now understood; it has none of the characteristics peculiar to *Aneides.* It is a form quite close to *Plethodon vandykei* of western Washington, with which it probably once formed a more or less continuous population throughout the former temperate forest which occupied the Great Basin, which now geographically (ecologically) isolates the two populations. The adults of *P. idahoensis* strikingly resemble in structure, color and color pattern, certain *P. vandykei.* We were unsuccessful in an attempt in 1948 (with R. C. Stebbins) to close the gap between the known ranges of the two forms by working in the conifer forests near the Canadian-Washington boundary line. A study of the relationship of *P. idahoensis* and *P. vandykei* would probably show that these geographically isolated populations are conspecific.[8]

Aneides hardii superficially resembles some members of the genus *Plethodon.* In the original description of *hardii,* Taylor (1941: 77) gives the following diagnosis:

> Fourteen costal grooves, the adpressed limbs separated by about 3½ costal folds; a well-defined median sulcus from between eyes to neck. Reduced number of mandibular, maxillary and premaxillary teeth, not exceeding 15 in either side of lower or upper jaw. Vomerine teeth, 5–6, the series separated from each other by a distance nearly as great as half the length of a single series, separated from parasphenoid teeth by a distance nearly equal to length of one series.

[8] Since writing this I have received 2 recently-collected and well-preserved specimens of *Plethodon vandykei* from James R. Slater, collected by him in Rainier National Park, Washington. These are representative of a large series collected near the confluence of Cataract Creek and Carbon River. In comparing them with *P. idahoensis* from the type locality they are found to be so similar to that population that it is recommended that the two be treated as conspecific (*Plethodon vandykei vandykei* and *P. v. idahoensis*). This inference probably more nearly approximates the present condition of potential gene exchange between these extrinsically isolated populations. This view is also supported by the fact that the other known amphibians occurring both in northern Idaho and the northwest coastal forest (*Triturus granulosus, Dicamptodon ensatus,* and *Ascaphus truei*) are conspecific.

The diagnosis above, and the description also given by Taylor, assure that the series analyzed in the present study, collected at the type locality of *hardii* in 1949, is of the same form as the type specimen of the species collected in 1940. Further, the diagnosis itself serves to indicate that *hardii* is a member of *Aneides*.

Skeletal features pertinent to the problem have been listed in Table I. The characters listed under *Aneides* and *Plethodon* serve to distinguish these genera from one another (see Cope, 1889; Dunn, 1926; Bishop, 1943). It will be noted that each characteristic of *Aneides* is as well a characteristic of *hardii;* this species possesses none of the diagnostic characters of *Plethodon* as distinguished from *Aneides*. Additional characters of *hardii,* including those of structure, pigmentation, behavior, and ecology, are all again characters shared with *Aneides,* and as with the skeletal characters in general they will be discussed at greater length elsewhere.

TABLE I

SKELETAL FEATURES DISTINGUISHING *Plethodon* AND *Aneides*

Plethodon	*Aneides*	Condition in *hardii*
Premaxillae not fused (2)	Premaxillae fused (1)	Premaxillae fused (1)
Maxilla normal with teeth on posterior portion	Maxilla with posterior portion knife-edged and edentulous	Maxilla with posterior portion knife-edged and edentulous
Terminal phlanges T-shaped	Terminal phlanges Y-shaped	Terminal phlanges Y-shaped

The cluster of 3 eggs was found within a large, moist, decomposing Douglas fir log lying under a canopy of Douglas fir and dwarf maple on a steep north-facing slope. Each egg contained a larva in an advanced stage of development with yolk sac still protruding from the mid-gut, and with the usual pair of large, flat, leaflike, trilobed allantoic gills. Also as in *Aneides,* the outer capsule has a relatively long pedicel. In this instance the pedicels were fused together at a common adhesive base which is the usual condition in *Aneides* (observations upon captive females of species of this genus while laying their eggs have disclosed the fact that fused or unfused pedicel bases result from the degree of movement of the female while she lays her eggs, singly and at short intervals). The pedicels were twisted about one another in the usual manner, suspending the embryos in a grape-like cluster from the roof of the small, moist, rotting wood cavity within which they were found; an adult female was close by the cluster. The eggs of *hardii* are in every respect like those of *Aneides*. Their microenvironment (including kind and type of "home log") is as in *Aneides ferreus*.

One need not necessarily observe the internal characters of *hardii* to realize its relationship. Profile, proportions, masseter development, sulci of the head and neck region, tapered and relatively short tail, well developed limbs, well developed digital sinusoids, prominently overhanging teeth, pigmentation, and behavior are all characteristic of *Aneides*. It is abundantly clear that *hardii* is unquestionably a well-marked member of the genus *Aneides* and not of *Plethodon,* as these genera are understood at the

present time, and it is, therefore, recommended that this species be accordingly recognized as *Aneides hardii* (Taylor) *comb. nov.*

Biogeography

The North American terrestrial plethodontid salamander genus *Aneides* is now considered to include five distinct species. The species disjuncts within this group raise several biogeographical problems. In order to understand more clearly the nature of some of these problems it is necessary first to outline the present ranges of the species (see Fig. 1).

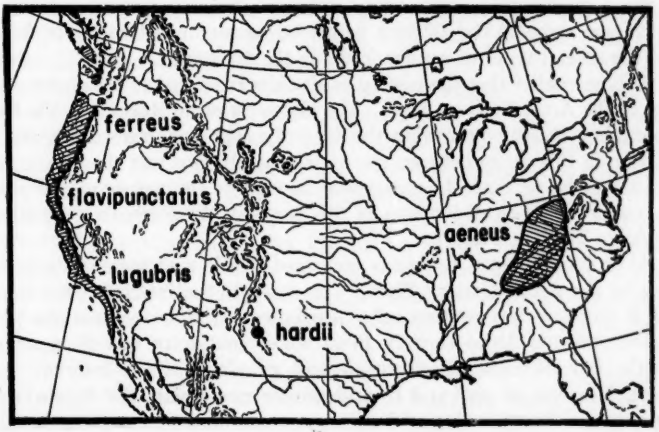

Fig. 1. Distribution of the species of *Aneides*

One of the species (*aeneus*) occurs in the Appalachian region of eastern North America; another (*hardii*) is in the southern end of the Rocky Mountain system in New Mexico; the remaining three (*ferreus, flavipunctatus, lugubris*) extend along the Pacific coast from Vancouver Island, Canada, southward into the northwestern corner of Baja California. *Aneides aeneus* survives today in what is a restricted Tertiary temperate paleoclimate in the restricted eastern sector of the former transcontinental Tertiary temperate forest (the Arcto-Tertiary Flora, see Chaney, Condit, and Axelrod, 1944: 6–12). Similarly, in the Far West, the relict *A. flavipunctatus* survives within the highly restricted and ancient coast redwood temperate environment, another segregate of the Arcto-Tertiary Flora. *A. ferreus* and *A. hardii* are closely associated with Douglas fir forest in the western area which also is a segregate community of the Arcto-Tertiary Flora. The more recently derived *A. lugubris* is today largely a semi-arid form, closely associated with live-oak woodland (mainly *Quercus agrifolia*), ranging from northwestern California just into northwestern Baja California. It occurs only at or near

the coast and in the north it ranges into the redwood and Douglas fir forests. These present disjunctions in range may well find their explanation in the history of Cenozoic environments. This belief comes from the fact that today all but one species of this genus are found in derivative communities of the Arcto-Tertiary Flora, and the other is on its borders in an ectone which has been in existence since the Oligocene.

In early Tertiary time the Arcto-Tertiary Flora, made up of conifers and deciduous hardwoods, ranged continuously across northern North America and extended south to approximately 50° Lat. on the coast, and to approximately 45° at the interior. By the Miocene it had extended farther southward at higher elevation and had shifted coastward to California. Later in the Cenozoic this forest was segregated into the various communities which now make up the different hardwood forests in eastern North America and the several types of conifer forest in the far west.

It is my belief that the history of *Aneides* is related to the Cenozoic history of the Arcto-Tertiary Flora. The discovery of an *Aneides* in the Rocky Mountains, thereby narrowing the formerly supposed transcontinental disjunction in this group between the Appalachian region and the Pacific coast, was not to be particularly unexpected in view of the nature of the present day major east-west disjunction of this genus in the segregate vegetation of the Arcto-Tertiary Flora.[4]

As explained above, *Aneides* is associated largely with segregate vegetation types of the Arcto-Tertiary Flora. This leads to the inference that *Aneides* was a more or less continuously distributed series of populations in the Transcontinental Arcto-Tertiary Flora whose continuity was disrupted during the late Miocene by savannah and grassland at the interior. Large geographic areas of semi-arid to arid climate now isolate the disjuncts from one another. These ecological barriers are exceptionally complete for plethodontid salamanders, and they date back into the Tertiary. The combination of a sedentary nature, comparatively low ability for individual dispersal and high ecological restriction by peculiarities of their spans of physiological tolerance, indicate that these animals probably dispersed at the approximate rates characteristic for the plants with which they were associated, and became similarly affected by subsequent climatic and physiographic change. In this connection perhaps the most striking similarity of plants and amphibia is the presence of a "wilting point," a characteristic not found in the dry-skinned reptiles, birds and mammals.

Paleobotanical evidence supports the hypothesis that separation of *Aneides* into an eastern and western area probably occurred during the late Miocene; it also indicates, as is discussed below, that the first isolation of the progenitors of the modern *A. hardii* occurred in all probability no later

[4] *Plethodon* has a similar disjunctive distribution. Additional populations of *Aneides* and *Plethodon* may yet be found on any of several of the Douglas fir capped mountain ranges of Arizona, New Mexico, and in the Sierra Madre Occidental of northwestern Mexico, where the prevailing climatic regime is also temperate and moist. The presence of *A. hardii* and other terrestrial plethodontids in other similarly situated ranges, is made possible in significant part by the occurrence of abundant summer rain. For those acquainted with their habits, the problem of finding these animals in such areas is mainly a matter of timing in hunting with regard to weather. Without considerable recent rain, collecting efforts are nearly hopeless. Thus with more exploration combined with better luck in timing than heretofore, in the higher, wetter mountains of Arizona, New Mexico, and northwestern Mexico, more plethodontid populations are undoubtedly to be discovered; local relicts of larger populations of once widespread Arcto-Tertiary forest faunas.

than during the Pliocene.[5] The present day Douglas fir forest, as it now appears in the form of essentially pure stands, has appeared only late in Cenozoic time and apparently only during the Quarternary (Axelrod, oral communication, November, 1949). Although *A. ferreus* and *A. hardii* are associated today mainly with Douglas fir habitats (to which environments, as a whole, they are highly adapted) it does not necessarily follow that these species are recent. Douglas fir as a component of the Arcto-Tertiary Flora dates well into the Tertiary and the degree of adaptiveness of these salamander species surely indicates a long evolutionary history in such an environment. The degree of morphological divergence and inferred genetic differences between *A. hardii* and *A. ferreus* are such that they are fully consistent with the conclusion that these populations were separated well before the Pleistocene. The discoveries of Pleistocene cool temperate forest components (for example, *Abies* and *Picea*) in Florida (Davis, 1946), Louisiana (Brown, 1936), and Texas (Potzger and Tharp, 1947) support the belief of a southward shifting of plant communities in the eastern and central United States. However, whether they can also be taken to indicate widespread temperate forest conditions at the interior is perhaps open to question. Moreover, Epling (1944: 169) has suggested that even during the pluvial periods the biota of the Pacific Coast may have been separated across the northwest from that of the Rocky Mountains, as now, by a relatively arid Basin and Range Province. Woodland or even more mesic forest may well have occurred during the Pleistocene in the intermontane areas separating the Rocky Mountains from the Pacific coast, and this is also discussed by Epling as a possibility.

With regard to the particular disjunction of *A. hardii* in the Sacramento Mountains of New Mexico, it is instructive to study the time-space relations of the Arcto-Tertiary and Madro-Tertiary floras of the Far West. It is particularly noteworthy that in Pliocene time the Sacramento Mountains and adjacent ranges are depicted by Axelrod (1949) as isolated areas of higher elevation supporting Arcto-Tertiary forest completely surrounded at lower elevation by Madro-Tertiary communities; i.e., during the Pliocene this area, inhabitated today by *A. hardii*, was first cut off from the main northern body of the Arcto-Tertiary Flora whereas in the Miocene it was in direct contact with it, being a southern extension of it. The paleobotanical record indicates a marked climatic change during mid-Pliocene. Axelrod (1947) has reviewed Middle Pliocene fossil floras from California, the Great Basin and the High Plains. Compared to Lower Pliocene climate, these clearly demonstrate lowered yearly rainfall, shifting seasonal distribution of rain, and increased ranges and extremes of temperature. They indicate that the major Tertiary floras of the western United States were differentiated

[5] This indicates a placing of certain events in the history of the Plethodontidae somewhat earlier in the Tertiary than is usually supposed (see Dunn, 1926: 12–13; Deevey, 1949: 1367). In considering the peculiarities of the family Plethodontidae and structural diversification within the group, and viewing biogeographical data in the light of paleobotanical data, I am of the opinion that the relatively specialized and advanced nature of the Plethodontidae has perhaps led to partly erroneous conclusions as to the antiquity of some of its genera and species. To be sure, certain of its units seem to be later, probably Quarternary, derivations. But all of them obviously have not had the same histories while many have had similar ones. Although this earlier dating of certain events differs in some respects with the opinions of Dunn, it is most importantly in full agreement with his conclusion that the family characters of the Plethodontidae must have been assumed at the latest in the early Tertiary.

into communities of essentially modern aspect by Middle Pliocene and succeeding climates. Again this is essentially what Epling (*supra. cit.*) concluded as a result of his studies of the present distribution of gene arrangements in the third chromosome of *Drosophila pseudoobscura* and the biota and climate of the Pleistocene. Taking all the information together, the relatively generalized *hardii* appears to be a marginally isolated species representing an *Aneides* population first geographically isolated during the early Pliocene.

The coincidence of latitudinal patterns of distribution of the herpetofaunal elements of the eastern and western parts of North America and Eurasia finds an explanation in the history of Tertiary environments. The simultaneous quantitative dissimilarity and certain qualitative similarity of the herpetofaunas of the eastern and western area of each continental region are also in agreement with the similar and often recurring patterns in the present floristic character of these areas. These present day latitudinal patterns common to many groups are clearly the result of historical factors common to both the plants and the animals. The existing populations are survivors of wider ranging ancestral communities which have become segregated in response to continuous climatic and physiographic change throughout the Cenozoic. Hence, such changes have resulted in differential survival of certain herpetofaunal components once more widely distributed in what are now restricted and derivative communities of the Arcto-Tertiary Flora. In addition a few relicts (best exemplified by *Alligator*) survive in the southeastern parts of these continents as remnants of wider ranging populations in the earlier Neotropical-Tertiary and Paleotropical-Tertiary floras.

Thus, the present latitudinal disjunctive distribution of *Aneides* falls within a fundamental pattern common to many plant and animal groups, a pattern in accord with the paleontological and meteorological facts and inferences therefrom to past climate throughout the Cenozoic. If we can regard the disjunctions in range as no younger than mid-Tertiary, as seems indicated by the distribution and history of the forest types with which they now occur, then it seems probable that the species of *Aneides* of the Pacific Slope, southern Rocky Mountains, and Appalachians have been diverging slowly through the last 20-30 million years in earth's history, and have not arisen during the Pleistocene.

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stemming from their common interests in problems of paleoclimate, biogeography and evolution.

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The Reptiles of Big Black Mountain, Harlan County, Kentucky[1]

By Roger W. Barbour

BIG Black Mountain lies in the southeastern section of Kentucky and adjacent Virginia, occupying parts of Harlan County, Kentucky, and Wise County, Virginia. The area designated "Grassy Gap" on the United States Geological Survey Estillville Sheet was selected as a base camp for field studies; this point lies directly south of Lynch, Harlan County, Kentucky, and is approximately half way from Lynch to Keokee, Wise County, Virginia.

Highway number 160, between Lynch and Appalachia, Virginia, crosses the mountain about 1.5 miles east of Grassy Gap. The area designated "The Doubles," some half mile west of the highway, is the highest point in Kentucky (elevation 4150 feet). A second peak, unnamed, southeast of Grassy Gap is indicated on the topographic sheet to have an elevation of 4150 feet, or more. On this second peak the Civil Aeronautics Authority maintains the Glenbrook, Kentucky, Visual-Aural Range Station; according to an engineer who surveyed the area for the station, the elevation of this peak is 4139.6 feet.

This peak lies very near 36° 54′ 51″ north latitude and 53° 20′ 40″ west longitude. With this peak as a center, a circle with a 4-mile radius would include practically every point at which collections discussed in this paper were made. The only collections made outside this area were at Exeter, Virginia; the Poor Fork of the Cumberland River between the towns of Cumberland and Harlan, Kentucky; and two areas on Pine Mountain, one near Cumberland and the other near Rosspoint, a few miles above the town of Harlan.

The period of July 19 to August 19, 1939, was spent in Harlan County, the time equally divided between the peak discussed above and the community of Rosspoint, on the Poor Fork of the Cumberland River. During this time amphibians, reptiles, birds, and mammals were collected.

On July 3, 1946, I accompanied a party of four to the mountain to stay until July 7. During this period the collection of mammals was stressed, but numerous amphibians and a few reptiles were collected. On June 4, 1948, my family and I made camp near the Glenbrook Visual-Aural Range Station and collected amphibians, reptiles, and mammals until the first of the following September. Collections made during this trip include approximately 300 mammals, 170 reptiles, 1350 amphibians, and 200 plants. The mammals and amphibians collected will be discussed in subsequent papers.

Big Black Mountain is the highest portion of the Cumberland Mountain Section, which has been ably treated by Fenneman (1938). For a discussion of the physiography of the area, the reader is referred to this work.

The exposed rocks of the area under consideration belong to the Pennsylvanian series; as the mountain occupies a central position in a syncline, the

[1] A portion of a thesis submitted to the graduate school of Cornell University, Ithaca, New York. The writer is indebted to Dr. William J. Hamilton, Jr. for advice, suggestions, and criticisms.

strata are essentially horizontal. The uppermost formation is the Harlan sandstone, some 880 feet in thickness, followed in order by Wise formation (1250 feet), Gladesville sandstone (120 feet) and the Norton formation (1270 feet). In terms of altitude, the strata of the mountain are: Harlan sandstone, 3270-4150 feet; Wise formation, 2010-3270 feet; Gladesville sandstone, 1890-2010 feet; and Norton formation, 620-1890 feet. For further information on the geology of the mountain, reference is made to the United States Geological Survey (1894). Bedrock is exposed in few places other than stream beds; the region generally is covered by a deep soil mantle.

No weather bureau data are available relative to the climate of the summit of Black Mountain. Natives report that in winter the snow drifts to a depth of 3 or 4 feet in the coves, and an overall 12-inch depth is not at all uncommon. During the months of July and August, 1948, daily temperature recordings were made in the early morning, the early afternoon, and the evening, at an elevation of 4050 feet. If it was felt that these times did not fall during the hottest and coldest parts of the day, additional recordings were made. These records indicate that during July the average temperature was 65.9° F., with a high and low of 90° and 48°, respectively. During August, the average temperature was 59.9° F., with a high of 90° and a low of 42°. The nearest United States Weather Bureau station to the area is at Benham, Harlan County, Kentucky.

Annotated List of Reptiles[2]

Sceloporus undulatus hyacinthinus (Green).—Twenty-seven were taken at elevations ranging from 1200 to 4000 feet. The fence lizard is fairly common about old fences, log piles, and standing trees in dry woods at the lower elevations. Although occurring to the very summit of the mountain, it is relatively rare at the higher elevations, particularly in the deep woods. The species is fairly common at all elevations along the bare rocks exposed in constructing the highway between Lynch, Kentucky, and Appalachia, Virginia.

Table I

Food	% by volume	% frequency
Hymenoptera (ants)	30.41	60.87
Arachnida (principally spiders)	17.14	30.44
Coleoptera	13.71	43.48
Hymenoptera (wasps)	7.82	13.44
Larval Lepidoptera	7.61	17.39
Orthoptera	4.10	17.39
Hemiptera	2.61	8.69
Diptera	.43	4.35
Unidentified insects	17.17	34.78

An adult female collected June 14 contained 10 eggs, averaging 8 by 15 mm.

The 5 smallest lizards collected in June average 47.6 (44-52) mm., snout to vent. Two taken in July average 57.5 (52–63) mm. The 5 smallest lizards

[2] All specimens are in the writer's personal collection.

taken in August average 27 (21-34) mm. Of the August specimens, the 2 smallest were taken prior to the middle of the month, the other 3 in the last half of the month. These data indicate that the eggs apparently hatch in late July or early August.

Twenty-nine stomachs were examined; all but 3 contained food. No attempt was made to identify the food items beyond order. Table I presents the food items found in 23 stomachs.

One of the most striking features of the stomachs examined was the variety of insects taken; all insects were small, but as many as 40 or 50 were commonly found in a single stomach.

Eumeces fasciatus (Linnaeus).—Known from a specimen collected June 14 from a dilapidated wooden fence at an elevation of 2300 feet in the valley of Looney Creek near Lynch. No others were observed. Apparently, this skink is uncommon in the Black Mountain area.

The specimen is 136 mm. in total length, and has a snout to vent length of 52 mm. The stomach contained 60 per cent Arachnida, 30 per cent adult Lepidoptera, and 10 per cent ants, by volume.

Carphophis amoena amoena Say.—The 23 worm snakes collected on Black Mountain are referred to this race; most of them agree with the characters of *amoena*. They exhibit the following internasal-prefrontal characters: completely separate, 16; united, 5; separate on left, ½ united on right, 1; ¼ separate on left, fused on right, 1.

Scale counts of 20 females are: ventrals, 116.9 (111-127); caudals, 69.9 (60-76). Scale counts of 2 males are: ventrals, 118.5 (112-125); caudals, 67 (54-80).

Measurements (in mm.) of 20 females are: total length, 211.5 (119-268); tail, 38 (24-50). Measurements of 2 males are: total length 190 (126-254); tail, 27.5 (21-34).

A series of 9 specimens collected at the north base of Pine Mountain, near Whitesburg, Letcher County, Kentucky, contains 6 with typical *amoena* headshields, one with typical *helenae* headshields, and 2 intermediates. Welter and Carr (1939) reported only *"helenae"* from Rowan County; it is apparent that the transitional area between *amoena* and *helenae* lies across eastern Kentucky.

Worm snakes were taken only at elevations ranging from 1800 to 2300 feet. Fourteen were beneath stones in a weedy pasture; one was under a stone at the edge of a little-used road; one was DOR; and 7 were in a potato patch in Lynch. No specimens were taken from woodland, although I have collected them often from wooded areas in other sections of Kentucky.

No egg-bearing females were collected.

The 7 specimens from the potato patch mentioned above were, according to the boy who found them, "in a ball, about 8 inches under the surface of the ground." They were taken on August 24, 1948. Of the 7, 6 were typical *amoena*, and one was typical *helenae*. Twelve of the snakes contained no food; 10 contained only earthworms in varying amounts.

Diadophis punctatus edwardsii Merrem.—Of the 53 ring-neck snakes collected, 47 have immaculate ventral surfaces, and 6 have an irregular row

of small black spots along the midline of the belly. In none is the neck ring broken in the middle, as in *punctatus punctatus*.

The width of the neck ring varies from 1 to 3 scales, the commonest number 2. Eight snakes have neck rings 1 scale wide; 21 have rings 1½ scales wide; 23 have rings 2 scales wide; and one has a neck ring covering 3 scales.

Scale counts of 17 males are: ventrals, 158.8 (151–174); caudals, 56.8 (38–68). Scale counts of 36 females are: ventrals, 163.6 (154–170); caudals, 56 (44–65).

Measurements (in mm.) of 17 males are: total length, 362.4 (154–454); tail, 78.6 (30–108). Measurements of 36 females are: total length, 348.1 (151–489); tail, 65.5 (25–102). Measurements of 13 egg-bearing females are: total length, 400.4 (329–486); tail, 75.7 (41–102).

Ring-necks were collected at elevations ranging from 2000 to 4100 feet in various situations, but always from under some type of cover, under stones, logs, pieces of bark, and between the trunk and loose bark of dead trees, either standing or prostrate. Specimens were most commonly found under stones in open fields, although some were taken in dense woods. One of the most profitable collecting procedures was to turn over stones along the roads of the area. The ring-neck snake appears to be the commonest reptile of the Black Mountain area.

Blanchard (1937) states that eggs are laid in late June or early July in northern Michigan. The smallest egg-laying female recorded by Blanchard was 317 mm. long. Twenty-seven females with a total length greater than 320 mm. were collected from Black Mountain. Of these, 13 were taken between June 8 and 24, and each of these females contained eggs. No egg-bearing females were collected after June 24, although 3 females were taken from July 1 to 15, 3 from July 16 to 31, and 8 from August 1 to 31. From these data, it is apparent that egg-laying occurs on Black Mountain in the latter part of June or early July, exactly as reported for northern Michigan.

A correlation between egg number and the size of the female snake has been pointed out by Blanchard (*loc. cit.*). Table II presents my data on this relationship.

TABLE II

No. of eggs	No. of specimens	Total length (mm.)	Tail (mm.)
2	1	377	77
3	6	376.3 (329–457)	73 (63–88)
4	2	392 (391–393)	61 (41–81)
5	3	441 (397–486)	82 (65–94)
6	1	461	102

The larger numbers of eggs are laid generally by the larger females. The smallest and largest egg-producing females, respectively, taken from the Black Mountain area are 329 and 486 mm. The average number of eggs contained by the 13 egg-bearing females was 3.77, ranging from 2–6.

No data are available regarding the hatching dates for these snakes. Blanchard (1927) gives the size range of young snakes as 115–143 mm. No snakes within this size range were collected. One 145-mm. specimen, taken

June 24, was undoubtedly hatched the preceding year. None smaller than 200 mm. was taken after August 15.

The visceral tracts of 53 specimens were examined; only 18 contained food. Items found in these stomachs are presented in Table III.

TABLE III

Food item	% by volume	% frequency
Plethodon glutinosus	21.0	22.2
Detritus (insect fragments, sticks, leaves, sand, gravel, etc., presumably from salamander viscera)	16.05	50.0
Desmognathus fuscus adults	14.33	16.65
Desmognathus fuscus larvae	5.5	5.5
Orthoptera (wood cockroaches)	7.77	11.1
Eggs of *Aneides aeneus*	7.5	11.1
Eurycea bislineata	7.5	11.1
Unidentified matter	20.27	27.75

Numerous natives throughout eastern Kentucky firmly believe that the ring-necks are the young of black snakes.

Opheodrys aestivus Linnaeus.—Known from a badly mutilated specimen found June 29, 1948, at an elevation of 1400 feet in the highway near Cumberland, Harlan County, Kentucky.

Coluber constrictor constrictor Linnaeus.—Four were taken at elevations ranging from 2250 to 3900 feet. An adult and 2 juveniles were found on separate occasions beneath stones in open areas. An adult male was found in an open pasture.

An adult female collected June 16, 1948, contained 22 eggs apparently ready to be laid.

Only one of 4 snakes contained food, the remains of an unidentified snake.

Elaphe obsoleta obsoleta (Say).—Six were taken from wooded areas, or woodland edges at elevations ranging from 1850 to 3750 feet. Several were observed dead on the highway over the mountain.

Food items in 3 stomachs were, by volume, 33 per cent *Pitymys*, 53 per cent nestling birds, and 14 per cent unidentified mammal remains.

Adult females collected June 14–July 8, 1948, showed no signs of sexual activity.

Lampropeltis doliata triangulum (Lacépède).—Four were collected, all at elevations less than 2250 feet. One was found in a residence in Imboden, Virginia; the others were beneath stones in a pasture near Lynch, Kentucky.

Two females collected in the first half of August, 1948, show no signs of sexual activity.

Stomach contents (by volume) of 3 specimens were 33 per cent unidentified snake; 33 per cent snake eggs, probably *Carphophis;* and 34 per cent unidentified animal remains.

Natrix sipedon sipedon (Linnaeus).—Eighteen were taken; this species is common in the larger streams of the area. Fourteen were collected in

three hours by turning over stones in a stretch of riffle on the Poor Fork of the Cumberland River a few miles below the town of Cumberland, Kentucky. No specimens were collected above 2450 feet, although a large individual was seen in a small pool in a mountain stream at an elevation of 3200 feet, on the south side of the mountain.

Stomachs of 8 specimens from the Poor Fork of the Cumberland River contained (per cent by volume): 50 per cent unidentified fish remains; 12.5 per cent *Rana* tadpoles; 12.5 per cent *Cambarus;* and 25 per cent unidentified detritus, presumably from the intestines of fishes. A specimen from a small woodland stream at an elevation of 2450 feet contained the remains of two large *Desmognathus fuscus.*

Storeria occipitomaculata (Storer).—Known from 2 females taken at elevations of 2250 and 4050 feet, respectively.

The 2 stomachs contained 50 per cent slugs, 10 per cent *Gryllus,* and 40 per cent unidentified animal matter, by volume.

One of the specimens was found crawling across a path skirting an open field; the other was under a flat stone in a sloping pasture.

Thamnophis sirtalis sirtalis (Linnaeus).—Twenty-nine were taken at elevations ranging from 1800 to 4000 feet. Although most common under stones in open areas, the species also occurred in woods. One specimen was under the loosely adhering bark of a dead leaning tree, some 4 feet above the ground.

On several occasions a garter snake and a ring-neck were found together under a single stone. In abundance, garter snakes apparently are exceeded in number only by ring-necks.

Seven gravid females were collected between June 23 and August 5. Six of these, all with nearly full-term embryos, were taken between July 21 and August 5, suggesting that the majority of the young are born in late July and early August. The number of embryos varied from 10 to 21, with a mean of 15.5.

Table IV lists the food items from the visceral tracts of 13 *Thamnophis* collected June 8 to August 28 on Black Mountain.

TABLE IV

Food item	% by volume	% frequency
Earthworms	38.46	38.46
Desmognathus fuscus	11.54	15.38
Plethodon glutinosus	11.54	15.38
Unidentified *Rana*	7.69	7.69
Orthoptera	6.15	7.69
Ants	.77	7.69
Unidentified	23.07	23.07

There is a possibility that the ants listed in the above table were from the visceral tract of some animal eaten by the snake. The orthopteran and the ants came from the same snake, and there was no indication whatsoever of any other food in the alimentary canal.

One garter snake was taken in the act of swallowing a large *Desmognathus fuscus,* on a sunny rock in the middle of a small stream, about 2:30

P.M. Examination revealed the snake had previously eaten 2 additional dusky salamanders.

Agkistrodon contortrix mokeson (Daudin).—Six were taken at elevations ranging from 1800 to 3200 feet. Copperheads were not observed above the 2250-foot contour on the north slope, but one was taken at an elevation of 3200 feet on the south slope of the mountain. Four were picked up dead on the highway; one was found in a building in Exeter, Virginia; the sixth was killed in an alley in Lynch, Kentucky.

According to the residents, copperheads are common in the valleys and on the lower slopes, but are rare, or even absent, at the higher elevations.

An adult female collected August 12, 1948, contained 3 well developed embryos. Another, collected August 16, 1948, had 6 embryos apparently ready for birth.

Stomachs of 2 copperheads contained remains of *Napaeozapus, Sorex,* and the larva of a sphingid moth.

Crotalus horridus horridus Linnaeus.—Eight were taken at elevations ranging from 2750 to 4000 feet. Most commonly found in dry, brushy areas, the rattlesnakes of Black Mountain are by no means confined there. One was taken from a stand of virgin beech-birch-maple woodland at an elevation of 3000 feet, on the north slope of the mountain. Natives report the rattlers common at all elevations; berry-pickers frequently encounter them.

No gravid females were taken. One specimen refused to rattle when captured; when released near camp and prodded into a coil, it began to rattle. As a general rule, however, the snakes commenced to rattle when approached within 4–6 feet.

Eight snakes containing food were examined. Table V shows the number of individuals of each item represented, and the frequency of occurrence of that particular item.

TABLE V

Food item	No. individuals	% occurrence
Clethrionomys gapperi maurus	7	50.0
Tamias s. striatus	3	37.5
Peromyscus maniculatus nubiterrae	1	12.5
Napaeozapus insignis roanensis	1	12.5
Snail (*Polygyra?*) (possibly from cheek pouch of *Tamias*)	1	12.5

I am informed by residents of the area that rattlesnakes play a prominent part in certain religious rites in some churches in the immediate vicinity of Black Mountain. One native told me he saw the pastor of a local church crawl under a "huckleberry" *(Vaccinium)* bush and after chanting the "magic words" capture a 4-foot rattlesnake with his bare hands.

According to the residents, there have been two fatalities from rattlesnake bites in recent years on Black Mountain. One man was bitten in the face as he stooped to get a drink at a spring; the other was bitten in the chest as he was clearing brush from a ledge.

Chelydra serpentina serpentina (Linnaeus).—Known from a single specimen taken July 22, 1948, fr[illegible] a puddle in the road at an elevation of 4050

feet. The carapace is 98 mm. in length, and 76 mm. wide. The stomach contained only *Cambarus* remains.

The distance from the temporary puddle where the turtle was caught to the nearest permanent stream, which is merely a small trickle flowing down the mountain, is at least three-quarters of a mile, through dense woods. No stream nearer than a mile and a half is known to support fishes. There are no permanent ponds within 5 miles of the spot where the turtle was collected.

Natives assert that snapping turtles are fairly numerous in the larger streams of the area.

Terrapene carolina carolina (Linnaeus).—Two specimens were taken at elevations of 1800 and 2300 feet, respectively. No others were observed. Carapace measurements of the 2 are: length, 130 (110–150) mm.; width, 98.5 (82–115) mm.

Contents of the stomachs (per cent of volume) were: snails, 60 per cent; *Cambarus,* 15 per cent; plant remains (leaves and stems), 12.5 per cent; *Gryllus,* 7.5 per cent; unidentified seeds, 5 per cent.

According to the natives, the box turtle is rare in the area but was said to be common in former years.

Graptemys geographica (LeSueur).—Known from a single young found dead July 18, 1948, in Looney Creek, in Lynch. It is possible that the turtle was introduced as a pet, either purchased locally or brought in from a more distant locality. However, in view of the fact that Welter and Carr (1939) took specimens from Licking River at Farmers and Fleming Creek at Sherburne, the species is listed as occurring in the Black Mountain area.

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Body Temperatures of some Marine Fishes[1]

By James E. Morrow, Jr. and Alexander Mauro

FISHES are usually considered to be poikilothermous animals, having a body temperature approximately the same as that of their environment. An exception to this generality may lie in the family Thunnidae, where body temperatures have been observed to be considerably higher than those of the sea. Until recently, this family has been classified with the Scombroidei (Jordan, 1923; Regan, 1909, 1929). However, Berg (1940) has placed the family in a separate order Thunniformes, "possessing a mighty cutaneous vascular system . . . Blood temperature higher than sea temperature . . . " A search of the literature has revealed a number of references to the body temperature of fishes, most of which indicate that there is a difference between the temperature of the fish and that of the water. These differences vary with different fishes and different authors from a fraction of a degree to as much as 10°C. Most of the older observations were made by means of thermometers (King, 1836, trout and whitefish; Davy, 1840, tuna; Kidder, 1879, 1880, 14 marine species; Harting, 1880; Dubois, 1898, cyprinids; Portier, 1903, 1908, tuna; Fibich, 1904, cyprinids and salmonids; Simpson, 1908, 8 marine species; Zirino, 1908, mullet, dory, sharks; Kishinouye, 1923, tuna; Hanson, 1929, tuna; and Legendre, 1934, tuna). This method is open to criticism on a number of grounds. It is, for example, hard to read a thermometer accurately when it is covered with blood and slime. There is the difficulty of keeping the fish quiet while making readings, and so on.

The use of thermoelectric methods is probably much more accurate. In this category, Regnard (1895), Rogers and Lewis (1916, goldfish), Azzi (1918, dogfish, eel, cichlid), Clausen (1934, 10 freshwater species) and Nielsen (1938, guppy) found only insignificant differences between fish temperatures and water temperatures. However, they used much smaller animals. It should be pointed out also, that stimulation, as from being caught in a net (Kidder, 1880), or from handling by the observer (Fibich, 1904), or excessive activity, results in an increase in temperature. This was confirmed by Clausen (1934), who used thermocouples in the stomachs of ten species of freshwater fish and found that while the temperatures tended to be the same as that of the water, the slightest stimulation, as by the passing of a shadow, led to a slight increase in temperature.

The present work describes a few results obtained by the Yale-New Zealand Expedition in the Bay of Islands in February, 1948. Observations made on 5 specimens of striped marlin (*Makaira mitsukurii*), caught on rod and line, were of particular interest, since these fish have generally been considered close allies of the tunas (Jordan, 1923; Regan, 1909, 1929). Additional observations were made on an ocean sunfish (*Mola mola*), a large fish of the open ocean, which was harpooned for the Peabody Museum.

Apparatus

All temperatures were taken by means of a thermocouple apparatus consisting of a thermocouple harpoon with No. 18 wire leads 20 feet long, a

[1] Scientific results of the Yale-New Zealand Expedition, 1948.

galvanometer, and a thermometer (Fig. 1). The thermocouple harpoon (Fig. 2) was turned from brass rod, and the copper-constantan thermocouple of number 18 wire was soldered inside at B. The upper opening, A, was closed with sealing compound to keep water out of the apparatus.[2]

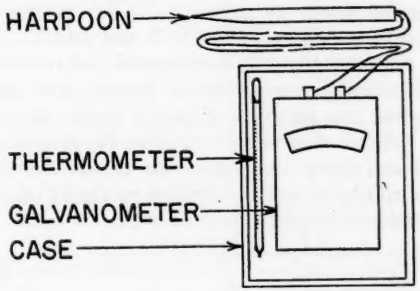

Fig. 1. Diagram of the thermocouple apparatus used in measuring body temperatures of large fishes.

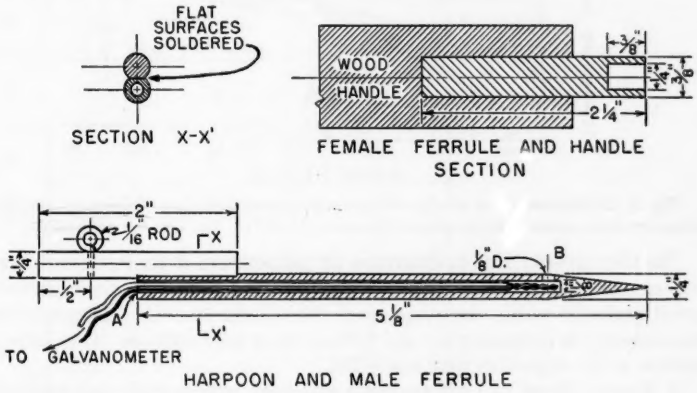

Fig. 2. Working drawing of the thermocouple harpoon.

Since all work was to be done at sea, it was necessary to keep the apparatus as simple as possible. Hence, a constant temperature junction was not employed to serve as reference. Instead, temperature differences were based on the air temperatures at the galvanometer, as determined by a thermometer mounted in the instrument box (Fig. 1), the galvanometer itself serving in place of a constant temperature junction. This method is permissible provided that temperature variations of the air are not too rapid with respect to the thermal time constant of the galvanometer. To test this, a harpoon was connected to the galvanometer and the whole apparatus placed in an in-

[2] We wish to thank Messrs. Arthur Bishoff, Clifford Allderidge and Stephen Mroz, of the Peabody Museum machine shop, for manufacturing the harpoons.

cubator. Observations at nine different temperatures, from 13.2°C. to 31.0°C., showed that 10 to 15 minutes were the most required for the instrument to reach thermal equilibrium with its surroundings.

The apparatus was calibrated by connecting a harpoon to the galvanometer and immersing the free end of the harpoon containing the thermocouple in a beaker of water. By adding ice or hot water to the beaker, its temperature could be varied between 6.5°C. and 39.5°C. Temperatures in the beaker were determined with a thermometer and recorded, air temperatures at the galvanometer were similarly treated, and the corresponding galvanometer reading was recorded. Figure 3 shows the calibration curve. The open circles indicate observations made on the ascending series of temperatures, the closed circles those made on the descending series. From these data, it was calculated that one division on the galvanometer scale corresponded to a temperature difference of 0.58°C.

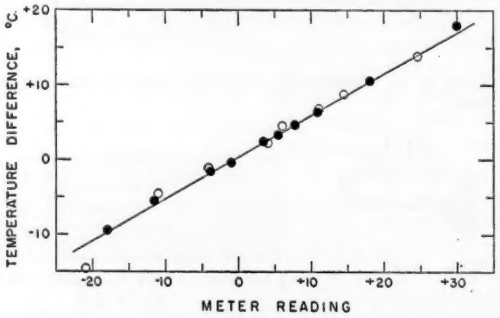

Fig. 3. Calibration curve of the thermocouple apparatus. One division of the galvanometer scale equals a temperature difference of 0.58°C. See text for discussion.

The thermometer used to determine air temperature at the instrument was checked against the surface water thermometer. Since the two thermometers agreed perfectly within the range used (10.3°C. to 30.5°C.), no correction was necessary in comparing air and surface water temperatures. Thus, errors inherent in the apparatus were negligible.

A Weston Model 440 galvanometer was used, with a scale that could be read with an accuracy of ± 0.1 scale divisions (about 0.06°C.). The thermometer was an ordinary −10°C. to +50°C. laboratory thermometer calibrated in 1°C. intervals which could be read to ±0.1°C. Thus, the error involved in reading the instruments was approximately ±0.16°C.

Results

Figure 4A is a graphic representation of the results obtained on 3 specimens of *Makaira mitsukurii* taken on February 22, 1948, near Cavalli Island. These temperatures were taken after the fish had been boated and are, therefore, the temperatures of dead or nearly dead animals. Number 65 (solid circles) was played on rod and line for 28 minutes. Two minutes after the fish was gaffed, the thermocouple was inserted into the dorsal muscle mass behind the pectoral fin. The temperature, as shown, was 6.2°C. above that

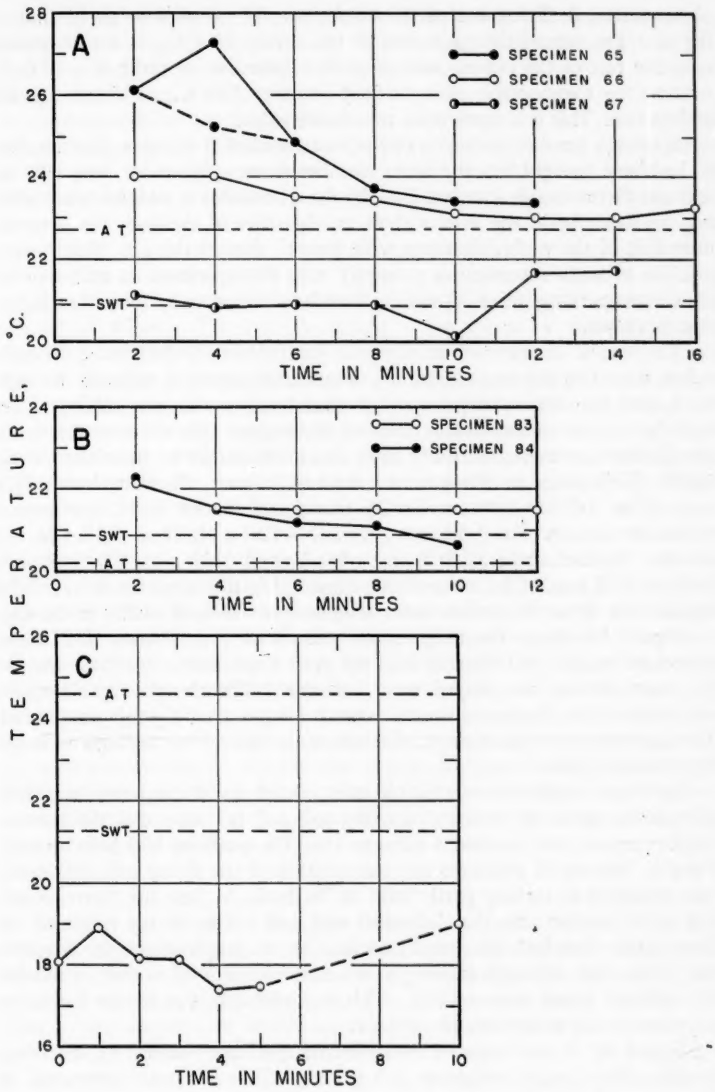

Fig. 4. Temperature records of fishes. A. *Makaira mitsukurii* specimens number 65 (solid circles), 66 (open circles), and 67 (half-closed circles). B. *Makaira mitsukurii* specimens number 83 (open circles) and 84 (solid circles). C. *Mola mola* specimen number 51. Line AT = air temperature; line SWT = surface water temperature. "Time in minutes" = elapsed time after beginning observations. See text for discussion.

of the water, declining during the subsequent 12 minutes to about that of the air. The second determination of this series, 27.3°C., is not consistent with the rest of the curve. Assuming that there was an error of +2°C. in reading the thermometer, this reading becomes 25.3°C., as shown by the broken line. This is a much more reasonable value.

Specimen number 66 (open circles) was hooked 9 minutes after number 65 had been brought into the boat. Number 66 was played for 29½ minutes and the thermocouple inserted into the dorsal muscles 6 minutes after boating the fish. Again the results show an elevation of the body temperature over that of the water, declining with time to that of the air. Had it been possible to begin recording as promptly with this specimen as with number 65, the temperature would doubtless have been found to be somewhat higher than is shown.

The record of specimen number 67 (half-closed circles) is of doubtful value, since this fish was caught 5½ hours later, nearly 8 miles to the eastward, and the water temperature at that locality was not taken. Other records made at corresponding times of day suggest that the water temperature in this case would not differ from that noted earlier by more than about 0.2°C. Field notes on this specimen read as follows: "Running home, 5:14 P.M., about halfway between Cavalli Island and Rocky Point, saw several marlin on surface. Put baits over. Mr. K— had a strike at 5:18 P.M. but missed. Another strike at 5:24 P.M., fish boated 5:43 P.M. Thermocouple inserted 5:45 P.M." The temperatures observed in this specimen do not differ significantly from the surface water temperature observed earlier in the day.

Figure 4B shows the temperature records of 2 specimens of *Makaira mitsukurii* caught on February 25, 1948, near Cape Brett. Specimen number 83 (open circles) was played for 15 minutes. The thermocouple harpoon was inserted into the dorsal muscle mass 2 minutes after the fish was boated. This specimen showed an elevated temperature, though not so high as in the two previous cases.

Specimen number 84 (solid circles), played for 23 minutes, was held alive in the water by means of a flying gaff and tail rope, and the thermocouple harpoon was inserted 4 minutes after the specimen had been secured. Possibly because of weakness and the position of the flying gaff, this specimen persisted in turning partly over on its back, so that the thermocouple had to be inserted into the abdominal wall and viscera in the region of the liver, rather than into the dorsal muscles. As the graph shows, the temperature of the fish, although starting at about the same level as that of number 83, declined rather more rapidly. This was probably due to the fish being alive and in the water (see discussion).

Figure 4C is the temperature record of specimen number 51, an ocean sunfish (*Mola mola*) weighing 269 pounds. This fish was harpooned on February 18, 1948, in Takou Bay. The field notes on its capture state: "Sighted a *Mola mola* 2:05 P.M. Harpooned 2:15 P.M. On board 2:45 P.M." While the fish was being brought on board, it did not struggle violently. The long time (half an hour) required to bring it into the boat was simply because it was practically impossible to secure a firm hold on the animal. It was finally necessary to tie it up with a barrel hitch and haul it on board

with a block and tackle. It was then photographed, and the temperature record begun some 10 minutes or so after boating. The galvanometer readings on the *Mola mola* indicate that its temperature was 2 to 4 degrees below that of the surface water. Unfortunately, there are no records of water temperatures at deeper levels on February 18, but records from February 22, made 3 miles northeast of Cavalli Island (about 4 miles north of the spot where this specimen was taken), are: surface, 20.9°C.; 15 fathoms, 19.4°C.; 30 fathoms, 16.1°C. The most reasonable explanation, then, of the observed results, is that this fish had recently come up from some deeper, colder stratum than the surface, and had not yet adjusted its temperature to the new level.

The irregular course of the record of *Mola* (see Fig. 4C) may be explained as follows. Previous to making observations on the sunfish, the apparatus had been kept in the cabin of the boat, which was about 4 degrees warmer than the air outside. Since the tests of the thermal time constant showed that the galvanometer changed temperature rather slowly, the same phenomenon would be expected here. That is, the thermometer registered the drop in air temperature faster than the change occurred within the galvanometer. Hence, temperature differences registered by the galvanometer were greater than those actually existing between the body of the fish and the air. This resulted in calculated temperatures lower than those actually present in the fish, and could also account for the irregular decline in the record. Assuming that the galvanometer did not change temperature at all during the first 5 minutes, the greatest error that could have been introduced from this source is 3.5°C. for the five minute determination. This would bring the temperature of the fish to 20.9°C., still 0.2° below the water temperature, and correspondingly lower at the earlier determinations. Since the galvanometer did change temperature so slowly, it seems probable that the first and last determinations in this series were fairly accurate, and that the true temperature of the fish was somewhere between 18°C. and 19°C. Modification of the apparatus to make a direct comparison of the temperatures of the fishes and of the sea would have avoided these fluctuations and is planned for future work.

Discussion

Of the 5 specimens of *Makaira mitsukurii*, 4 showed temperatures considerably higher than that of the sea. Considering the large size of these fish (8 feet, 3 inches to 8 feet, 10½ inches in standard length and 184 to 283 pounds in weight), and the fact that they had been exercising violently just prior to the temperature determinations, this is scarcely surprising. In any individual, an increase in the metabolic rate involves an increase in the rate of heat production. But, disregarding the effect of accessory cooling mechanisms, the loss of heat will depend very nearly directly upon the surface area, which, of course, remains constant. As a result, an increase in the metabolic rate of such an animal brings about a rise in temperature within the body.

The high specific heat of the water in which aquatic poikilotherms such as fishes live, probably maintains the temperature at the surface of the body

at a level comparable with the water temperature. But if heat is being lost to the environment, it must come from within, and a gradient from a higher temperature within to lower temperature at the surface is to be expected, provided the fish is big enough. As Gunn (1942) pointed out, large animals "may be hot inside and cold near the surface, the cold environment cooling the surface tissues while leaving the interior quite warm." Since the present results deal with temperatures 3 inches below the surface (the harpoon was always inserted to its full length), some elevation of temperature is to be expected.

The rather more rapid decrease of temperature in specimen number 84, which was held alive in the water, was also to be expected. Immersion would have cooled this specimen more rapidly even had it been dead. Since it was also alive and respiring, there was additional cooling through the re-distribution and removal of heat via the gills and circulatory system.

At first glance, the results described and discussed here seem to be at variance with the results of those workers who used comparable methods for measuring body temperatures and to agree with the older, less accurate thermometric determinations. None of the thermoelectric measurements cited earlier yielded significant temperature differences between fishes and their environment, while the majority of the thermometric measurements did produce such results. However, all the thermoelectric work was done on small fishes. Portier (1908) and Simpson (1908) concluded from observations that the greatest temperature differences were to be found in the larger fishes. This can also be demonstrated on theoretical grounds.

The production of heat in an animal is a function of mass, but the loss of heat is a function of surface area. Since area increases as the square of the linear dimensions and mass increases as the cube, it follows that as an animal grows, its capacity for heat production increases faster than that for heat loss. Assuming that all fish in the same water have the same temperature, this means that the increased capacity for heat production in big fish is largely unutilized. But it also means that when that capacity is more nearly fulfilled, as in extreme exertion, large fish will produce much more heat than will small fish. Since these large fish have, relatively speaking, a smaller capacity for heat loss, they will develop higher internal temperatures. When these factors are brought into consideration, the results presented here are not greatly opposed to those of such workers as Clausen (1934), Rogers and Lewis (1916), and others. Although the present data are somewhat scanty, they suggest that, under normal conditions of activity, the body temperature of large fishes such as the marlin does not differ greatly from that of the environment.

Summary

1. An apparatus for the thermoelectric measurement of body temperatures of large fishes is described.

2. Body temperatures were recorded for 5 striped marlin (*Makaira mitsukurii*) and one ocean sunfish (*Mola mola*).

3. The data show that under conditions of violent activity, striped marlin can develop a body temperature higher than the temperature of their environment.

4. It is suggested that under normal conditions, the body temperature of striped marlin does not differ greatly from that of the environment.

5. The single record for the ocean sunfish, of particular interest because of the low temperature shown, is best interpreted as indicating movement from deeper, colder water.

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Gametogenesis of *Polyodon spathula* (Walbaum): a Basis for Regulation of the Fishery

By R. WELDON LARIMORE

FOR two centuries, since the fishes of the Mississippi Basin were first crudely described by early American explorers, *Polyodon* has captured the interest of naturalists, embryologists and anatomists. New attention was focused on the paddlefish during the first decade of this century when it attained importance among the valuable commercial species of the Mississippi Valley. Thus, from the standpoint of both zoology and the management of fisheries resources, the development of *Polyodon* is of considerable interest. The following investigation of gametogenesis in the paddlefish discloses some information concerning size at sexual maturity. This may be useful as a basis for fishery regulation.

Acknowledgments

Mr. P. G. Barnickol, formerly with the Illinois Natural History Survey and now Superintendent of Fisheries Research, Missouri Conservation Commission, furnished first-hand information on the present status of the paddlefish fishery; he also supplied materials collected during a survey made co-operatively by the Iowa Conservation Commission, the Illinois Department of Conservation, and the Illinois Natural History Survey. The problem was suggested by Dr. George W. Bennett and supported by the Illinois Natural History Survey. Acknowledgment is made of the assistance in histological methods given by Professor F. B. Adamstone, of the Zoology Department, University of Illinois.

History of the Fishery

Large numbers of paddlefish were caught when the fishermen of the central United States first began utilizing the vast aquatic resources of the Mississippi River; however, this species had little market value until about the year 1900. Possibly the weird appearance of the paddlefish with its enormous rostrum kept it, at first, from being considered a valuable food fish. But when the paddlefish was accepted in the markets, the fishery for it developed rapidly along the Ohio and Mississippi rivers, and the species was reported by Evermann (1902) as "more sought after than any other species in the Mississippi basin." Not only did the meat bring a good price, but also the roe taken from ripening females was highly valued as caviar. By 1915 the roe brought two dollars a pound and the flesh around ten cents a pound; in some places (Hussakop, 1910) even the heads and fins, usually discarded, were boiled for their oil.

Polyodon fishermen used special rigging capable of hauling in a thousand pounds of paddlefish at a netting. Seines as much as 2 miles long and 30 feet deep, reeled in on a barge, herded the paddlefish in from open waters. These fish showed a peculiar trait when surrounded by the seines, for they became quiet upon striking the net and floated to the surface of the water. Taking advantage of this strange behavior, the fishermen dragged nets through the water and periodically collected the subdued fish in small rowboats. Alexander (1914) mentioned that this method was followed by many commercial fishermen in the lakes of Louisiana.

Heavy fishing reduced the commercial catch of *Polyodon* in some localities, even as early as 1910. Annual statistics on the number of pounds marketed reveal a continuous decline during the past twenty years. As the catches of paddlefish became smaller and smaller, fewer fishermen maintained the special equipment needed for their efficient handling. Although the catch of paddlefish has fallen off since it first became an important market species, it continues to hold a prominent place among the commercial fishes of the Mississippi. Along the southern tributaries of the Mississippi, present-day fishermen commonly use snag lines to catch paddlefish, a method which depends upon the fish becoming snagged on dangling unbaited hooks. Large catches of paddlefish are still taken occasionally in seines, although they are more or less accidental in general commercial netting operations.

The independent paddlefish industry no longer exists as it did during its colorful rise to importance at the beginning of this century.

Breeding Habits

Very little actual information now exists concerning the spawning habits of *Polyodon*. Stockard (1907) was unable to find ripe paddlefish in any of the lakes on which he collected in Louisiana, Mississippi and Arkansas, and concluded that paddlefish which have grown to mature size in lakes do not spawn. However, Stockard recorded one observation of paddlefish from the Mississippi River entering Lake Washington, Mississippi, April 10, and on April 14, spent females were collected, suggesting that *Polyodon* leaves the river and moves into backwater lakes to spawn. Other records support this idea.

Several reports have been made of paddlefish spawning, but authentic observations of the actual procedure are still lacking. However, Alexander (1915) concluded from collections made during the breeding season that they move in schools when depositing and fertilizing their eggs, usually over hard sandy bottoms. He mentioned that during the middle of the spawning season, whenever any spawners are taken in a seine, the catch will invariably include a number of both mature and immature fish of both sexes, as well as recently spent ones.

Macroscopic examinations of the gonads of mature paddlefish indicate that the species spawns as early as March in the southern part of its range and as late as May in the north. More specific information on the development of the reproductive products of mature and immature paddlefish was obtained through histological studies of the gonads of fish taken in the upper Mississippi River during April and May, 1946. The following description of the gametogenesis of *Polyodon* is based on these specimens.

Collection and Preparation of Material

Material for this study was collected in 1946 by Mr. P. G. Barnickol and other members of a co-operative Mississippi River survey supported by the Iowa Conservation Commission, the Illinois Department of Conservation, and the Illinois Natural History Survey. Specimens listed below in Table I (excepting one taken April 17 at Burlington, Iowa, and two taken May 8 at New Boston, Illinois) were selected at random from a seine haul containing 1,204 pounds of paddlefish, made May 14 at New Boston, Illinois, on the Iowa side of the river. The haul was made by Bart Tompkins, using a 200-yard seine of 2½-inch mesh; the catch also included carp, buffalo, and a few sheepshead.

Each paddlefish was weighed and measured; samples of gonads were removed and fixed in A. F. A. solution for several weeks and then stored in 70 per cent alcohol. Later the tissues were embedded in paraffin, sectioned at 10 microns, and stained with Heidenhain's iron alum haematoxylin.

Gross Anatomy of Testis

The testes in *Polyodon* consist of two ribbon-like bands extending anteriorly along the lateral margins of the dorsal surface of the body cavity. These branches are connected only at their extreme caudal portions where

they unite and turn ventrally to open to the outside. The flattened bands are suspended by two mesorchia from the dorsal wall and are concealed ventrally by heavy layers of fat. In an immature specimen, the testis is scarcely distinguishable as a thin ribbon along the dorsal edge of the large fat mass. Stockard (1907) found that this fat may be so extensive in a fish in good condition that it may make a male appear like a female gravid with eggs. He examined one male paddlefish in which the fat masses around the testes weighed 3¾ pounds. Microscopic examination shows that the fat adjacent to the testis has projections extending into the edge of the gonad and between the marginal tubules. The connective tissue covering of the testis extends also over the mass of fat.

TABLE I

LENGTHS AND WEIGHTS OF MISSISSIPPI RIVER PADDLEFISH FROM WHICH GONAD SAMPLES WERE TAKEN

Total length, inches	Weight, pounds	Sex	Date and Locality
32.5	6.10	M	May 14, 1946 New Boston, Illinois
39.3	9.45	M	" " "
39.5	8.60	M	" " " "
40.5	10.15	M	" " " "
40.5	13.00	M	" " " "
41.2	13.75	M	May 8, 1946 " " "
41.5	11.00	M	May 14, 1946 " " "
41.5	13.12	M	" " " "
42.6	13.00	M	" " " "
43.3	14.45	M	" " " "
44.0	10.80	M	" " " "
45.5	13.50	M	" " " "
46.2	12.25	M	April 17, 1946 Burlington, Iowa
46.3	15.25	M	May 14, 1946 New Boston, Illinois
35.8	7.95	F	" " " "
38.3	8.50	F	" " " "
39.0	10.50	F	" " " "
40.0	11.10	F	" " " "
40.5	11.00	F	" " " "
42.6	14.15	F	May 8, 1946 " " "
45.8	15.75	F	May 14, 1946 " " "
47.5	18.45	F	" " " "
50.5		F	" " " "
57.2	41.00	F	" " " "

In *Polyodon* the testis is of a primitive type, composed of numerous convoluted tubules enclosed in a sac of connective tissue. The germinal epithelium lining the tubules may consist of cells in any one or all of the stages of spermatogenesis, the relative number of cells of each stage varying with the seasons. The position of a cell in the cross section of a tubule is of little value in identifying its stage of maturation but usually the later stages are found bordering the lumen of the tubules. In the testes of *Polyodon* clusters of cells occur, all of which are in the same stage of maturation; these clusters have developed through repeated divisions from one original gonium. The maturation of one cluster of spermatogonia appears to be independent of the others within the same tubule, for, as previously mentioned, several different stages of sperm formation may be adjacent to one

another. As a result of this type of maturation, it is possible to observe all stages of spermatogenesis in one mature testis. In this material from *Polyodon* there was no way of tracing an individual tubule; however, I believe that the blind ends of the branches always contain small masses of spermatogonia, for in all microscopic sections, even of very mature testes, one can find a few small tubules containing only spermatogonia.

Maturation Stages in Spermatogenesis

The maturation of male germ cells in *Polyodon* follows a series of stages easily recognized as spermatogonia, primary spermatocytes, secondary spermatocytes, spermatids, and the mature sperms. The particular characteristics of these stages are described below.

Spermatogonia form an inner layer of cells along the walls of the epithelium lining the tubules (Pl. I, Fig. 1). A spermatogonium is usually polygonal in shape and averages 8 microns in size, with its nucleus containing but little chromatin material. A single dark nucleolus, prominent in the lightly staining nucleus, often is near to the nuclear wall. Tubules in immature testes and terminal portions of the tubules in maturing testes may contain no germ cells other than these polygonal spermatogonia.

The spermatogonia increase in size and become primary spermatocytes (Pl. I, Fig. 2). The primary spermatocytes average larger than the cells in the other stages of the maturation process, ranging from 9 to 11 microns in diameter. Nuclei of these cells vary from 6.5 to 8.5 microns in diameter; each nucleus contains one or two large nucleoli and a reticulate arrangement of heavy chromatin strands.

Primary and secondary spermatocytes are difficult to separate, except that the secondary spermatocytes (Pl. I, Fig. 3) are smaller, their nuclei are smaller (4.5 to 6 microns in diameter), chromatin material is more concentrated and the clusters contain more individual cells.

Spermatids may be recognized by the appearance of their nuclei, which are oval and have the chomatin material clumped to one side in an elongated, irregular mass (Pl. I, Fig. 4). The outlines of the cells cannot be readily determined. The nuclei are difficult to measure because of their irregular shape, but range from 3.75 to 4.50 microns in diameter. In the mature spermatids, the nuclei and chromatin are contracted into rod-shaped masses indicating a transition into elongated spermatozoa.

The final product of spermatogenesis, the spermatozoa, are formed by transformation of the spermatids. The immature spermatozoa are no longer arranged in clusters; they frequently may be seen in pairs but are usually in large masses in the lumen of the tubules. These immature spermatozoa have no tails and appear like simple rods that take a heavy stain. With maturation the head becomes elongated and enlarged anteriorly and is tipped with a small spherical piece that probably contains the acrosome. Attached posteriorly to the darkly staining sperm head is a mid-piece which takes a lighter stain. These parts together average 5½ microns. Projecting from the mid-piece is a long filamentous tail, between 13 and 16 microns in length. Thus the mature spermatozoa are nearly 20 microns long and form dark masses in the lumen of the tubules (Pl. I, Fig. 5).

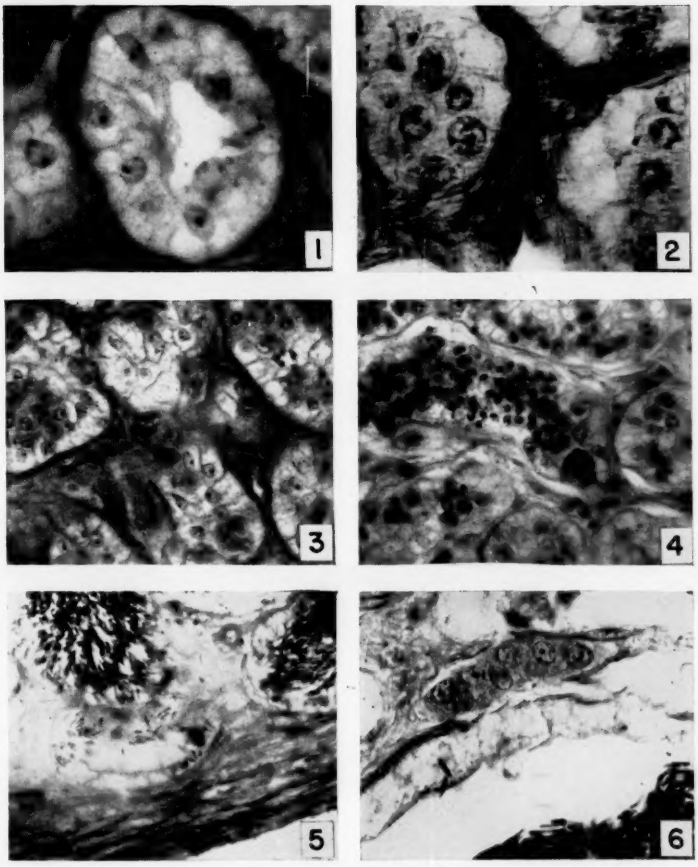


Fig. 1. Portion of testis showing polygonal shaped spermatogonia along periphery of tubule. The nuclei contain little chromatin but have large, prominent nucleoli. Magnified × 970.

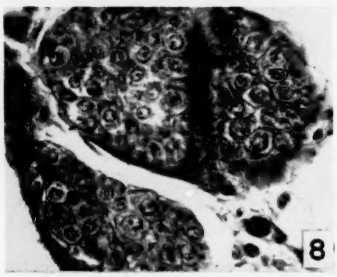
Fig. 2. Large primary spermatocytes with reticulate nuclei. This stage usually exists in groups of eight cells. Magnified × 570.

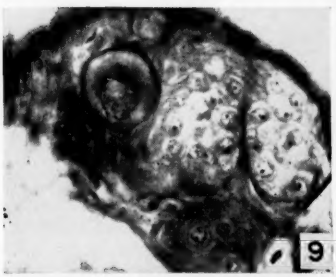
Fig. 3. Dark clusters of secondary spermatocytes, mostly in lumen of tubule. Magnified × 440.

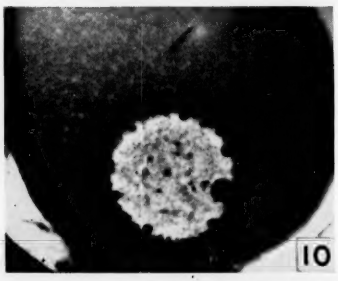
Fig. 4. Spermatids with chromatin material clumped to one side in an irregular mass. Magnified × 440.

Fig. 5. Portion of outer edge of testis showing connective tissue enclosing the tubules and masses of spermatozoa. Magnified × 440.

Fig. 6. An elongated mass of interstitial cells in a mature testis. Magnified × 970.







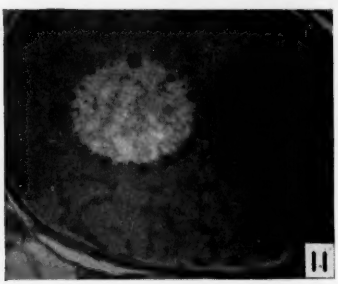


Fig. 7. Cross section of developing ovary showing lamellae lined with oocytes. Magnified × 35.

Fig. 8. Ovary with tightly packed clusters of oogonia. Magnified × 440.

Fig. 9. Developing oocyte and adjacent clusters of oogonia. Magnified × 440.

Fig. 10. Oocyte with many large nucleoli. Magnified × 440.

Fig. 11. Ovum showing reticulated cytoplasm. Magnified × 440.

Fig. 12. Clusters of eggs as they appear in a ripe ovary. Magnified × 10.

Interstitial Tissue

The occurrence of interstitial tissue in fishes has been a point of considerable controversy. In this material the interstitial tissue is clearly evident in the developing testes (Pl. I, Fig. 6). The cells are in clumps averaging 52 microns long and 9 microns wide. The cytoplasm stains more heavily with Heidenhain's haematoxylin than does that of other cells of the testis.

Size and Age of Males at Maturity

The testes of three of the specimens examined in the study contained no spermatozoa, the tubules being filled with spermatogonia and spermatocytes. These fish ranged from 32.5 inches to 42.6 inches in length. The smallest male that contained mature sperm was 39.3 inches long and weighed 9.45 pounds. Adams (1942) studied the growth of *Polyodon* by examination of otoliths and dentary bones and found that the paddlefish required about seven years to reach 40 inches in length. Although Adams secured no data on sizes of males at maturity, he found the females matured when about 42 inches long. The material examined for this study indicates that the males attain sexual maturity when around 40 inches in length and, according to Adams' calculations, when about seven years of age.

Gross Anatomy of Ovary

The ovaries of *Polyodon* are paired structures similar in position to the testes, but more lateral than the male organs. Immature ovaries are covered on the under side by large masses of fat, such as were described for the testes, completely concealing the undeveloped gonads of a fish in good condition. Stockard (1907) did not mention extensive fat development on the ovaries, possibly because he was interested primarily in examining ripe females which do not possess such excessive amounts of adipose tissue. The interesting fact that undeveloped ovaries have excessive fat, whereas ripe ovaries do not, was brought to my attention by Mr. P. G. Barnickol, who examined many paddlefish during his work on the Mississippi River. The fully developed ovary is so much enlarged by the accumulated eggs that it fills all available space in the body cavity and greatly distends the abdomen. Stockard (1907) examined several females containing as much as 16 pounds of roe, and believed the maximum yield is even greater.

Before the ovary in the paddlefish becomes gravid with eggs, the lamellae extend out freely into the abdominal cavity from the attached core in the form of many compact leafy folds. Each lamella has its margin lined with the young oocytes (Pl. II, Fig. 7). Upon maturation of the ova the distended ovary loses its lamellated form and becomes a mass of tightly packed black eggs enclosed in the ovarian membranes.

Descriptions of Developing Oocytes

Oogonia begin their development in immature gonads as clusters of tightly packed cells (Pl. II, Fig. 8). The smallest of these that can be recognized with certainty are 8 microns in diameter, and, because of the compact assemblage, are polygonal or otherwise irregular in shape. A centrally located

round nucleus about 5 microns in diameter occupies a large part of the cell. The nucleus usually contains only one dark nucleolus and not much chromatin material. Boundaries of these are difficult to distinguish but, even though Scharff (1888) spoke of such a cell as a "wall-less ovum," the limits of the membranes can be determined.

The first change observed in the clusters of oogonia is an increase in the size of these cells accompanied by a gathering of chromatin granules along the periphery of the nucleus. The largest oogonium measured in one such group was 13.8 microns in diameter with a nucleus (8.47 microns in diameter) proportionately smaller than in cells described above.

At this point, one oogonium in a cluster becomes very much larger than the others and appears to crowd the other cells (Pl. II, Fig. 9). This cell enlargement probably represents a change from oogonium to oocyte. Oocytes of 20 microns in diameter usually possess four large nucleoli within the nucleus. By the time they attain 30 microns, they appear independent of surrounding germ cells and are enclosed in a distinct follicular membrane. The nuclei contain lamp-brush chromosomes and many nucleoli, two or three of which are larger than the others. In 60-micron oocytes, these larger nucleoli are even more noticeable and may be 3 microns in diameter (Pl. II, Fig. 10). An oocyte of this size has a definite outline, an oval nucleus, and takes more stain than in earlier orders.

As the oocyte increases greatly in size, the follicular membrane becomes heavier and the nucleus, growing at a slower rate than the cell, takes up proportionately less and less of the cell volume. Table II shows the increase in nucleus and cell diameter as the ovum grows, as well as the per cent of total cell volume represented by the volume of the nucleus.

TABLE II

RELATIVE DIAMETER OF OVUM AND NUCLEUS AND PER CENT OF TOTAL CELL VOLUME REPRESENTED BY THE NUCLEUS

Diameter of ovum (microns)	Diameter of nucleus (microns)	Volume of nucleus / Volume of cell — per cent
8.0	5.0	24.4
13.8	8.5	23.4
50.0	27.5	16.6
180.0	75.6	7.4
2000.0	500.0	1.6

Small vacuoles appear in the cytoplasm of 190-micron ova. Vacuolization begins as a ring of minute clear spots around the nucleus. The vacuoles do not seem to increase in size until the oocyte is considerably larger.

By the time the ovum becomes 250 microns in diameter, there are two distinct membranes around the developing egg, an outer follicular membrane of flat cells and an inner layer often spoken of as the zona radiata. There are no radiations in this inner layer, as are characteristic in the fully formed membrane. In oocytes of this size there are branching threads in the cytoplasm, giving the cell a reticulated appearance (Pl. II, Fig. 11). These non-

granular threads may be merely a result of improper fixation of the cytoplasm, although it cannot be explained why they appear only in eggs of this size. Since yolk formation was not studied in *Polyodon*, it is not known what significance (if any) these cytoplasmic strands have in the development of yolk granules. Although some cytologists believe the yolk develops from nucleoli which migrate through the nuclear wall, the many large nucleoli found outside the nuclei studied here were believed to have been mechanically displaced in sectioning.

The ripe eggs of *Polyodon* are dark, nearly spherical (Pl. II, Fig. 12), and measure 2 mm. in diameter. The ovum is filled with yolk, the yolk granules being larger near the vegetal pole than around the animal pole. The nucleus is 0.5 mm. in diameter, slightly oval, and located well toward the animal pole of the egg. All of the large chromatin granules are arranged just inside the periphery of the nucleus. The membranes surrounding the egg are fully formed, with the outer theca folliculi relatively thin and composed of flattened cells. The zona radiata is divided into two layers, called by some cytologists the externa and interna. Parallel radial canals give this membrane its characteristic appearance. The innermost layer, which directly surrounds the yolk mass, is the true vitelline membrane and is often termed the zonoid.

Size and Age of Females at Maturity

The gonads examined in the study of oogenesis have shown that the female paddlefish from the Mississippi were over 50 inches in length when ready to spawn. Table I shows that the female specimens ranged in size from 35.8 inches up to 57.2 inches. Microscopic examination gave no indication that any of the specimens between 35.8 inches and 50.5 inches would have spawned the season when taken. Since the one large female (57.2 inches) contained ripe eggs, it was concluded that the developing oocytes of the smaller fish would be carried over to the following year.

Adams (*op. cit.*) determined the age of several mature females and found, as previously mentioned, that they attain a length of 42 inches before becoming sexually mature. Adams calculated from rings on the otoliths that a fish of this size must be nine or ten years old. Since females have been found with ripe eggs at 42 inches and others 50 inches long with only poorly developed ovaries, one must conclude that maturity is attained within this length range. These lengths are considerably above the average size of paddlefish netted in recent years for market, and indicate that the majority of these fish taken by commercial fishermen have never spawned. Such information has led to recommendations for raising the size limits on paddlefish. However, these protective measures may be of limited value, because the fish are very sensitive to being netted and often die before their removal from nets and seines. Increased length limits will not prevent the paddlefish from becoming entrapped in commercial fishing tackle, with many sublegal fish being wasted.

Summary

1. *Polyodon* supported a valuable independent fishery in the Mississippi River Basin between 1900 and 1925. Although there has been a steady

decline in the commercial catch, the paddlefish continues to rank with the important market species.

2. The testes of male *Polyodon* collected in the spring of 1946 were found to contain cells in all stages of the maturation process, from spermatogonia to mature spermatozoa. Most of the males from 39.3 to 46.3 inches in length contained mature sperm, although two males longer than 39 inches were immature.

3. Interstitial tissue was definitely present in the testes.

4. The ovaries of a female *Polyodon,* 57.2 inches long and 41.0 pounds in weight, contained mature eggs when collected on May 14, 1946. Ovaries of females from 35.8 to 50.5 inches in length (collected on the same date) contained no mature eggs, but showed oogonia and oocytes, although no yolk production was evident. These fish were judged incapable of spawning in 1946.

5. Male paddlefish mature at smaller sizes than females, but both sexes probably reach maturity when between 39 and 55 inches total length. Thus the present Fish Codes in force in the states bordering the upper Mississippi River allow many paddlefish of immature sizes to be marketed.

6. Even though increasing the length limits will not prevent small paddlefish from becoming entrapped in commercial fishing tackle and suffering some loss, a restriction on marketing immature sizes would save a great percentage of the small fish. In actual practice, because only a small portion of the commercial catches are sexually mature fish, such a protective restriction would almost eliminate the marketing of paddlefish, and possibly allow it to increase in numbers.

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Carotenoid Pigmentation of the Pomacentrid Fish *Hypsypops rubicunda*[1]

By Henry Kritzler,[2] Denis L. Fox, Carl L. Hubbs and Sheldon C. Crane [3]

DEEP-ORANGE color, due to copious quantities of xanthophyll esters of the taraxanthin class (Fox, 1936), renders the adults of the garibaldi, *Hypsypops rubicunda* (Girard), perhaps the most conspicuously brilliant fish along the rocky shores of southern California and northern Baja California. The intensity of the pigmentation raises numerous problems, bionomic as well as biochemical.

Our hearty thanks are extended to the following: The National Research Council Fellowship Board in the Natural Sciences, for the opportunity given one of us (H. K.) to spend the year of 1946-47 in residence at the Scripps Institution of Oceanography; the Rockefeller Foundation, for the support of the research program of one of us (D. L. F.) on the comparative biochemistry of marine biochromes, which program included later phases of this investigation; the Steinhart Aquarium of the California Academy of Sciences, for two specimens; Bayard H. McConnaughey and Arthur S. Lockley, for valuable assistance in several quantitative phases of the investigation; to Mr. Lockley, further, for permission to state briefly some results obtained by him in experiments on another species and for an examination of the gut contents of garibaldis; and to Jack Prodanovich and associated "Bottom Scratchers" of San Diego, for procuring needed specimens.

Developmental Color Phases and Their Biological Significance

Juvenile and half-grown garibaldis contrast sharply with the bright orange adults. They would, in fact, appear to be distinct species, were it not for the gradual transitions between the successive color phases. The adaptational relationships of these phases must be quite different.

At standard lengths from about 10 to 40 mm., the young, seemingly in recapitulation, rival the brilliant varicolored pomacentrids of the coral reefs (Smith, 1883). The general body color grades from pale to deep orange or scarlet, which merely sets off the spots and streaks of scintillating blue. In the upper anterior parts, back to the front part of the dorsal fin, the blue predominates. The blue is a structural color reflected from guanin platelets that allow the passage of the longer light waves, which are absorbed in the underlying sheet of melanin (Fox, 1947: 464).

The blue markings persist, but decrease in number, relative size and intensity, through the half-grown stages. Long after the blue spots on the body disappear, as the adult stage is reached, blue edgings persist on the fins, particularly along the front margin and the filament of the pelvic fin and along the outer edge of the anal.

As the blue markings become restricted at a standard length of about

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5 cm., the ground color becomes duller and browner. Except when exposed to bright light, which causes the blue spots to gleam, the half-grown garibaldi is a relatively drab fish, contrasting as strongly with the blue-spangled young as with the unicolored though brilliant adult. The dullness of the half-grown, as contrasted with the brightness of the adult, is due not only to a larger quantity of black melanin granules, masking the orange carotenoids, but also to the much lower xanthophyll content of the skin (Table I and Figs. 5–6).

TABLE I

CHANGES WITH AGE IN TOTAL SKIN XANTHOPHYLL CONTENT OF THE GARIBALDI

The values for each even 100 g. weight are taken from Figs. 5 and 6, using the line fitted by eye to the plotted determinations.

Weight of Fish, g.	Total Skin Xanthophyll, mg. per 100 g.			
	In Fish	Increment	In Skin	Increment
100	9.4	9.4	49	49
200	16.0	6.6	74	25
300	19.8	3.8	87	13
400	22.2	2.4	94	7
500	24.0	1.8	98	4

With the attainment of maturity, at a weight of about 300 g., the melanin obviously decreases and the xanthophyll definitely increases, to produce a much brighter and more orange fish.

Changes in habitat and in habits accompany the color transformations. Like the early juveniles of some other pomacentrids, the blue-spangled young at first appear to be neritic, but at a small size they take up an abode on the rocky reefs, between and just below tide limits. They live under and near ledges and about large crevices, and dart into shelter almost instantaneously when closely approached. In habitat and habits as well as in the brilliantly blue markings they seem to recapitulate the characteristics of the group as a whole. Nearly all pomacentrids are brilliant tropical reef fishes.

A somewhat similar coloration, with bright blue markings on a somewhat orange ground, characterizes the very young of the blacksmith, *Chromis punctipinnis* Cooper, the only other pomacentrid that occurs in northern Baja California and in southern California. In that species, however, the young congregate in vast mid-water swarms, as one of us (C. L. H.) has learned while diving with goggles. Furthermore, the *Chromis* rapidly transforms into a black-spotted fish, only moderately bright blue, which swims about the rocks at various depths and occasionally moves near the surface.

The dull half-grown garibaldis are quite inconspicuous, even to a "skin diver," for they slink through the crevices and vegetation of the reefs. The adults, in contrast, often leave their own crevices and display their colors over open spots on the reefs. That they have very strongly developed territorial habits has become evident from observations in aquaria as well as in nature.

The biological significance of the color must change as the garibaldis pass through their successive color phases. The juvenile color, scintillating blue on an orange to scarlet background, might be ascribed to recapitulation. But the colors are even more brilliant than those of the young of most tropical damselfishes. Neo-Darwinists will assume a positive selection for brilliance. In fact, a simple case of environmental mimicry may be involved. Occupying the range and habitat of the young garibaldis are several species of attached algae that shine with a very similar metallic blue. On the basis of specimens submitted, one of these has been identified for us by Dr. E. Yale Dawson as *Chondria californica* (Collins) Kylin; others, as species of *Rhodoglossum, Gigartina, Egregia,* and probably other genera. Some reef collectors assert that the shining blue fish actually associate with the algae of similar sheen, but we have not noticed a definite close association. Be that as it may, the environment of the young garibaldis does have splashes of metallic blue that, to human eyes at least, very closely resemble the most conspicuous element in the color of these fish. Furthermore, young garibaldis usually stay quiet, like the algae, close to the rock surface, except when they dart rapidly into crevices.

The dull brownish-orange colors of the half-grown are very inconspicuous in the retreats of the reefs that the species at this stage inhabits. Since the bright sunlight does not strike in these shadows, the remaining spots do not reflect intense blue. At this stage the fish is no doubt subject to predation and its color is obviously protective.

Due to their relatively large size, very deep body and strong fin spines, the adults must enjoy a greater immunity from predation by fish-eating birds and fishes. Their habit of remaining near their home-territory crevices and of dashing into these when alarmed, gives them much protection from larger predators, notably the California sealion, *Zalophus californianus* (Lesson). The adaptational significance of the unusual color of the adult garibaldi seems to lie in the circumstance that "the flashy orange . . . appears to advertise the presence of this fish, which boldly fights to defend its home territory" (Hubbs, 1947: 929). Its color, on this explanation, will be comparable to the color displays of birds that advertise their presence in their own defended territories.

Biochemical Studies

Many questions have arisen concerning the quantity, the chemical nature and the metabolic relations of the carotenoid pigments that render the adult garibaldi such a conspicuously orange fish. We have wished to determine: (1) age differences and individual variations (and, perhaps, geographical differences) in the xanthophyll content of garibaldis in nature; (2) the persistence or loss of integumentary xanthophyll in captivity; (3) the kinds and numbers of xanthophylls; (4) the persistence or loss of these biochromes in the skins of specimens kept on a carotenoid-free diet; and (5) whether carotene, supplied as the only type of carotenoid, might be either stored as such or converted into xanthophyll.

Procedure

Accordingly, carotenoid extracts were prepared from the skins of freshly caught individuals and of specimens maintained on controlled diets. The

skin alone was analyzed, because in this as in numerous other species of fish, the integument represents by far the chief permanent depot for dietary carotenoids. The underlying flesh is white.

In preparation for the analysis of their carotenoid pigments, each specimen was weighed and then killed by pithing. The skin was loosened by the immersion of the fish for 3 or 4 minutes in boiling water. The whole skin (including the white lower layers), the scales and the fins were removed, weighed and ground under initially absolute ethanol in the presence of anhy-

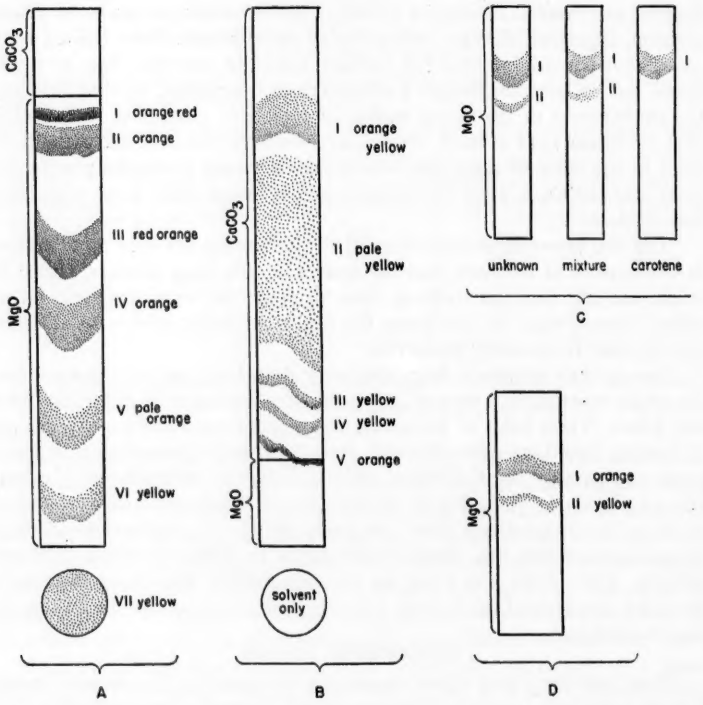

Fig. 1. Chromatograms obtained in fractionation of carotenoids of *Hypsypops rubicunda*.

drous Na_2SO_4. Extraction of the solid material was completed in a Soxhlet apparatus with petroleum ether (b. r. 30°–60° C.). The two extracts were finally combined, and the alcohol was removed by washing with aqueous NaCl solution. The resulting orange-red petroleum ether solution was washed with distilled water, dried with pure crystalline NaCl and adjusted to a definite volume.

Aliquot samples were evaporated under illuminating gas. The oily pigment residues were dissolved in CS_2. Their absorption maxima and quanti-

ties were then determined with the use of a Bausch and Lomb visual spectrophotometer. Concentrations were calculated by employing the estimated specific absorption coefficient (182.5) of violaxanthin or taraxanthin at 470μ. This estimated average value is based on numerical comparisons between absorption curves for taraxanthin (Zechmeister, 1934) in CS_2, violaxanthin in ethanol, and the specific absorption coefficients of such better known carotenoids as zeaxanthin, lutein and cryptoxanthin in CS_2 and ethanol (Strain, 1938).

Chemical, chromatographic and spectroscopic studies were made of all extracts.

AGE, INDIVIDUAL AND GEOGRAPHICAL DIFFERENCES IN XANTHOPHYLL CONTENT

Analyses of 29 freshly caught garibaldis, all from the vicinity of La Jolla, California, and varying in weight from 64 to 515 g., prove clearly that the total xanthophyll content increases notably with age, at first very rapidly, then more slowly. Because of the wide scatter of the data, the average values, as graphed and tabulated (Figs. 5–6, Table I), are rough approximations. Refinements of data, however, cannot be expected to modify the conclusion just stated. The increase in the relative content of carotenoid pigment with age is in agreement with the observed transformation of the dull-orange half-grown fish into the brilliant orange adult.

The determinations of xanthophyll content fluctuate very widely at any given size of fish. On the basis of the scatter of the data for freshly caught fish, as graphed on Figures 5 and 6, we estimate that individual fluctuations of about 50 per cent are not extremely rare. Errors in determination may be involved, but great fluctuations are also indicated by mere observation, for at any size some fish are much more orange than others.

There may also be some geographical variation in the content of carotenoid pigment, but the evidence as to temperature relationship is conflicting. When collecting fish specimens near Punta Abreojos, about half way down the coast of Baja California, where sea temperatures are definitely warmer than in southern California, one of us (C. L. H.) noted that the many garibaldis taken averaged much brighter and more orange than in California. On the other hand, adult garibaldis from La Jolla that were kept in the warm salt system (70°–75° F.) at the Steinhart Aquarium in San Francisco consistently lost their bright orange colors much more rapidly and to a greater degree than they do in the generally cooler water of the aquaria at Scripps Institution. Within a few months they became much paler and in 3 to 6 years became bleached to pale lemon-yellow. Two that had bleached out for 2 and 3 years, respectively, were sacrificed for xanthophyll analysis and their skin was found to contain only 19 and 12 per cent of the estimated average content for their respective weights (data plotted as triangles on Figs. 5–6). Several specimens caught in 1947 were placed as a trial in the cold salt system and after a year retained much more orange pigment than had those kept in the warmer water. The factors responsible for the concentration of carotenoid pigments in the skin are apparently not simple and certainly are not well understood.

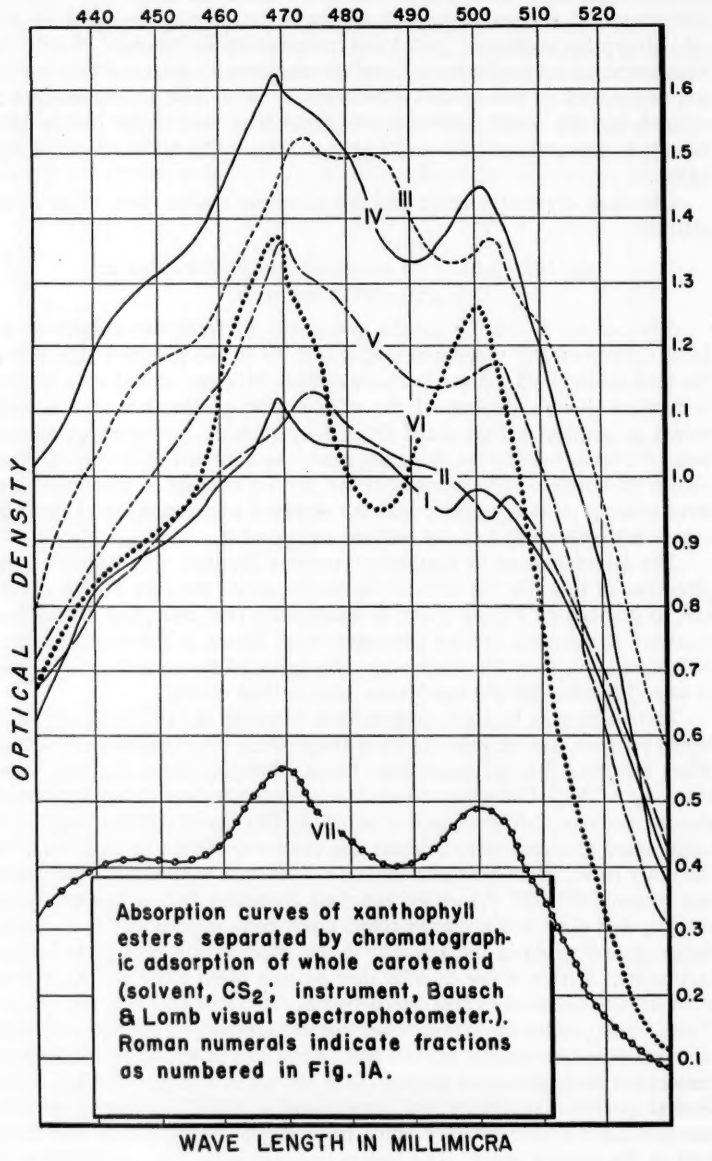

Fig. 2. Absorption spectra of xanthophyll esters from *Hypsypops rubicunda*.

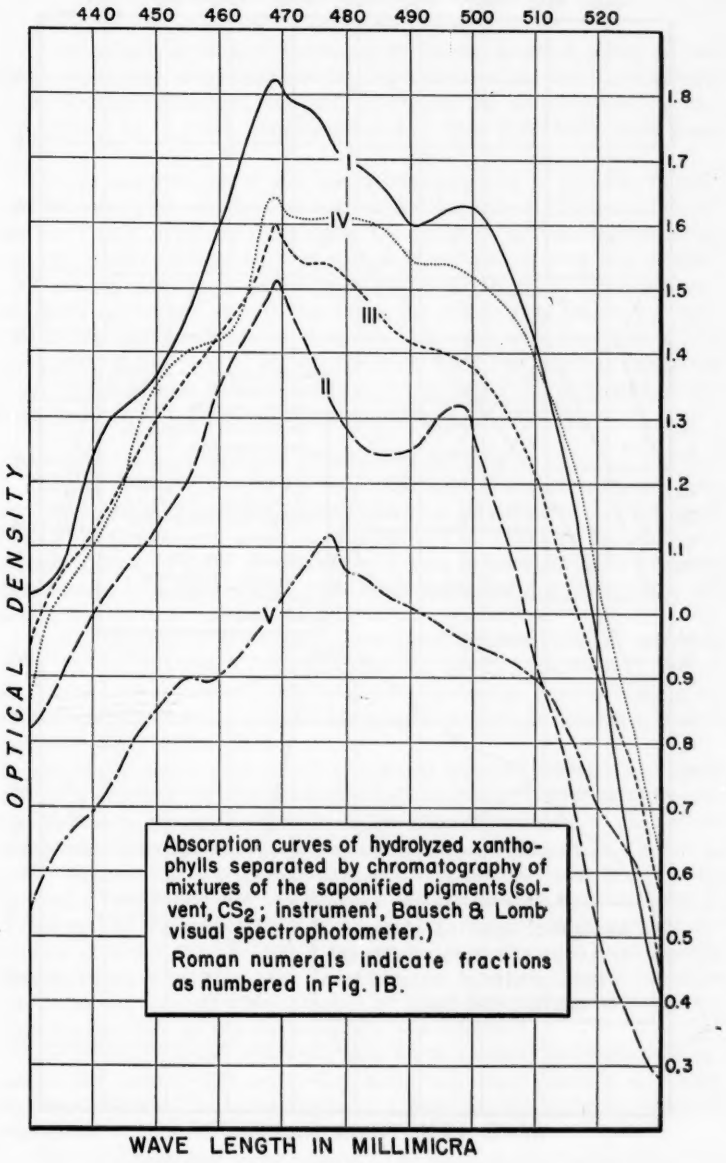

Fig. 3. Absorption spectra of free xanthophylls from *Hypsypops rubicunda*.

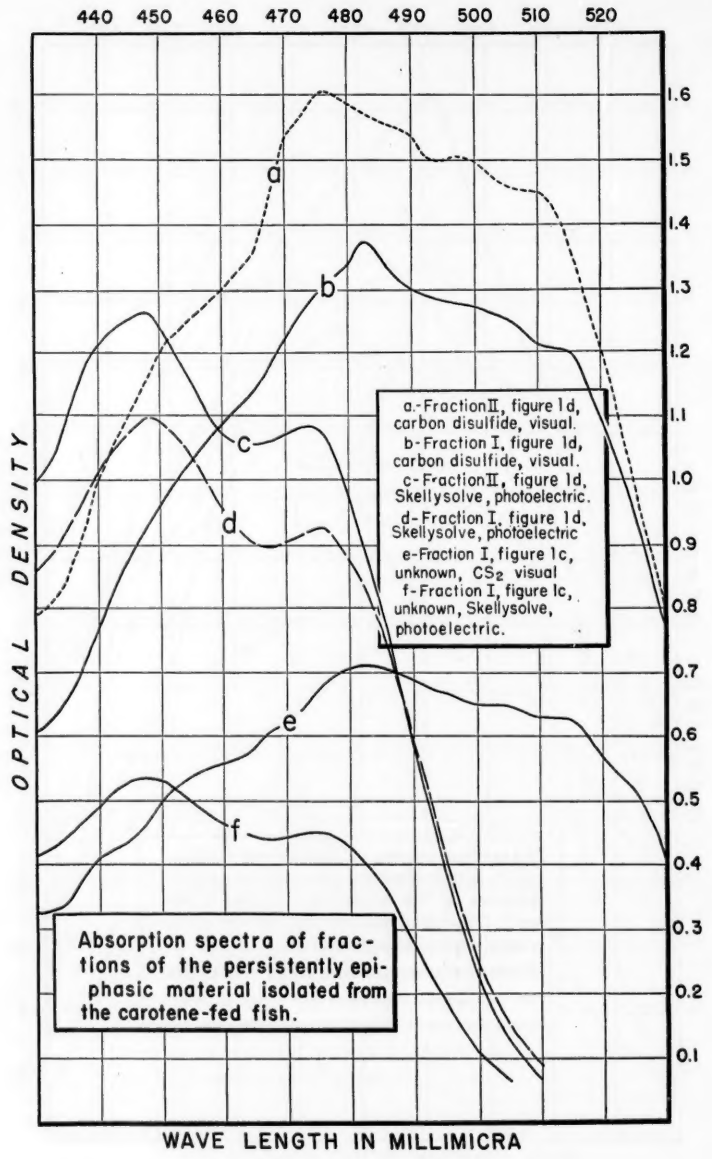

Fig. 4. Absorption spectra of fractions of the persistently epiphasic material isolated from the carotene-fed fish.

PERSISTENCE OF XANTHOPHYLL PIGMENT IN CAPTIVITY AT LA JOLLA

In the aquaria at Scripps Institution garibaldis, as noted above, do not bleach out so fast or so much as they have done on the warm salt system at the Steinhart Aquarium. In fact, good color has been retained by fish kept as long as 10 years. No analytical data have been taken from these fish.

For the interpretation of the feeding experiments it is desirable to estimate the loss of skin xanthophyll content that might be attributed to laboratory conditions. Since on the average the fish with carotene-supplemented and with carotenoid-deprived diets both ended up with a lower skin xanthophyll content than the controls (the freshly caught fish), it is possible that the loss of xanthophyll in both was due to the conditions of captivity (Table II). In the carotenoid-deprived test the 3 fish that were kept 108 to 252 days appear to have lost on the average about 5 per cent, whereas those kept 323 to 326 days seem to have lost about 28 per cent. The fluctuation is too great, however, to warrant placing much reliance on these figures.

KINDS OF CAROTENOIDS PRESENT

Portions of whole pigment extracts, subjected to partition between petroleum ether and 90 per cent methanol, proved to be epiphasic save for small traces. Samples of each phase, transferred to CS_2, exhibited the same absorption spectra (Fig. 2). Protracted hydrolysis in alcoholic KOH rendered hypophasic all of the material from fresh specimens and from those fed carotenoid-free diets (cf. Fox, 1936).

Chromatography of the whole unhydrolyzed pigment yielded 7 fractions (Figs. 1A, 2). Fraction VI was adsorbed but weakly; fraction VII, not at all. These 2 were the most alkali-resistant components. Chromatography of the individually hydrolized and subsequently recombined fractions yielded 5 elutable zones. (Figs. 1B, 3).

The altered phasic behavior of the pigment fractions following hydrolysis substantiates the earlier conclusion that the carotenoid biochromes of *Hypsypops rubicunda* are xanthophyll esters. The observation that 5 of the 7 chromatographic fractions showed absorption maxima at 469 and at 500–501 μ in CS_2 suggests that the major quantities of the material exist in nature as esters of a taraxanthin-like xanthophyll. The 2 remaining fractions (Fig. 2, II and III) of the unhydrolyzed whole pigment, which exhibit maximal absorption at about 472 and 503 μ, are similar in this respect to eloxanthin (Strain, 1938). Since they were present in relatively small quantities, their absorption characteristics were masked by those of the dominant biochrome when the spectrum of the whole pigment was examined.

The chromatographic separation from the hydrolyzed material of 4 taraxanthin-like xanthophylls may reflect either the initial presence of 4 such chemical individuals or isomerization of a single compound during chemical procedures.

The fish xanthophyll is not believed to be identical with taraxanthin. The absorption maxima of both compounds agree with those of dinoxanthin, recovered by Strain, Manning and Hardin (1944) from the fresh-water dino-

flagellate *Peridinium cinctum,* as well as from the marine algal cells living commensally in the sea anemone *Cribrina xanthogrammica.*

The garibaldi xanthophyll, like dinoxanthin and taraxanthin, differs chemically from the spectroscopically indistinguishable violaxanthin (from the pansy, *Viola tricolor*) in that the latter gives an intense blue color when its ethereal solution is shaken with concentrated HCl.

No evidence was found of any qualitative changes with age in the carotenoid pigments of the garibaldi. Though analyses of the very young have not been made, it is thought that they too have the same kinds of carotenoids as do the adults.

FEEDING EXPERIMENTS

Eleven specimens were maintained at Scripps Institution in individual compartments in tanks receiving a continuous supply of fresh sea water. To avoid dietary complications, the light was held below the threshold for the development of algae, which the garibaldis would probably have eaten. Five were fed twice weekly on a diet substantially devoid of carotenoids, consisting of white "fillet of sole" (prepared from several pleuronectids), supplemented with a paste compounded of oleomargarine, $CaCO_3$, bleached wheat flour, glucose, and dried, fat-free fish meal. The diet fed to the 6 other fish differed from the foregoing only in that it included, blended with the paste, a mixture of α- and β-carotenes (1 : 9) in the equivalent of 1.0 mg. per meal per fish. The carotene-supplemented portion was fed first and was invariably consumed before hunger had abated; the remainder of the meal consisted of the control diet. The food was presented in portions small enough to be swallowed whole, one at a time, until the animals would take no more. Throughout the experiment the food was consumed with evident relish, as most of the fish became accustomed to taking the morsels at the water surface as they were offered. From the appearance of the fish it was thought that the experimental diets were adequate. All seemed to remain in good general health and activity. Their satisfactory condition was further suggested by the fact that the average ratios of skin weight to total weight for the two experimental groups (0.23 and 0.24, respectively) were only slightly higher than the average for the controls (0.22).

The differential effects of the carotene-supplemented and carotenoid-deprived diets (Table II) are difficult to evaluate quantitatively, for the following reasons: (1) the pronounced change with age in xanthophyll content (not appreciated when the experiments were run) makes comparison with a norm hazardous, particularly since the fish fed the carotene-supplemented diet were all smaller than those deprived of carotenoids; (2) the normal fluctuation of the controls also gives a dubious base line; (3) the enormous fluctuation in the analyses of the experimental animals renders comparison dubious; (4) the number of fish in each experiment was obviously too small, especially since 3 of the 5 deprived of carotenoids were kept for a shorter period than the others and may owe their lesser loss of xanthophyll to this fact (as indicated above). Since repetition of the experiment is not feasible now, however, the data are briefly summarized and discussed.

It is very probable that the fish deprived of carotenoids in their diet suffered some loss of xanthophyll from their skin. The 2 kept on this diet

for 323 to 326 days were estimated to have lost respectively 15 and 41 per cent, as roughly computed by comparing the analyses of these fish with the estimated norm (Fig. 5). They may have lost more than did the larger of the fish fed the same diet with carotene added.

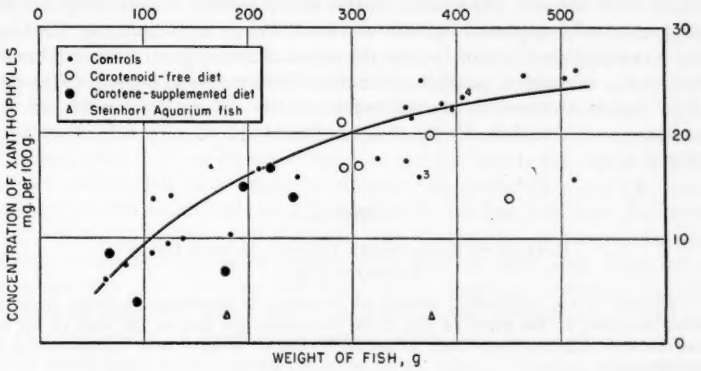

Fig. 5. Concentration of xanthophylls in mg. per 100 g. of whole fish.

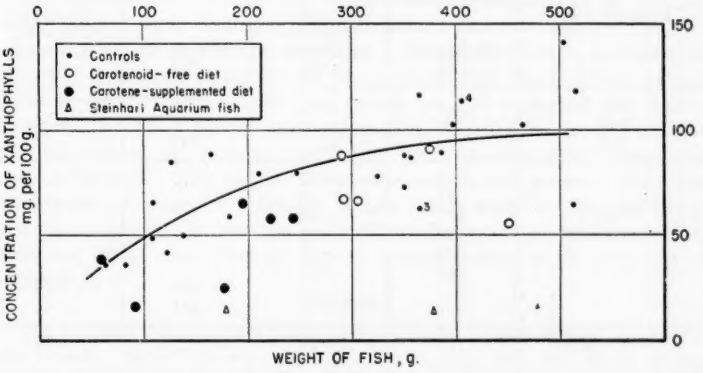

Fig. 6. Concentration of xanthophylls in mg. per 100 g. of skin. Two of the dots on Figs. 5 and 6 represent (as labelled) 3 and 4 controls, respectively, of indicated average weight.

The apparent loss of xanthophyll in the fish fed on a diet including carotene indicates that the carotene supplement did not render the animals capable of maintaining normal concentrations of skin carotenoids. More than this we may not conclude from the available quantitative data.

Some qualitative tests yield a more definite conclusion, namely, that a

small part of the carotene in the diet of one group was apparently retained and deposited in the skin. The biochromes extracted from the integument of the carotenoid-deprived group did not differ qualitatively from those of the controls. Similarly, the hydrolyzable portions from the skins of the carotene-supplemented group exhibited the same series of xanthophylls. But, unlike all of the rest, the animals in this group yielded also an unhydrolyzable, persistently epiphasic fraction which proved to be β-carotene. Its identity was established by conducting the mixed chromatogram test with known β-carotene, wherein a possible artifactual isomer also appeared (Figs. 1C, 1D). Spectrophotometric measurements of the absorption maxima of this fraction, in CS_2 and in Skellysolve, confirmed its identity with β-carotene (Fig. 4 e, f).

TABLE II

CHANGES IN XANTHOPHYLL CONTENT OF SKIN UNDER DIFFERENT DIETS

Changes in the xanthophyll content are expressed as percentage deviation from the values indicated by the curve on Fig. 5, on the assumption that at the start of the experiment each fish had an average xanthophyll content. Weights were taken at close of experiment.

Days on Diet	Carotene-supplemented Diet		Carotenoid-deprived Diet	
	Weight of Fish	Change in Pigment Content (%)	Weight of Fish	Change in Pigment Content (%)
108	...	....	375	− 9
160	...	....	290	+ 8
252	...	....	292	−15
	61	+31	...	....
	93	−56	...	....
303 to	177	−54	...	....
326	195	− 5	...	....
	222	− 1	...	....
	244	−22	...	....
	...	....	306	−15
	...	....	451	−41
Average	...	−18	...	−14*

* Average indicated loss was 5% for specimens kept 108 to 252 days; 28% for those kept 323 to 326 days.

REMARKS ON CAROTENOID METABOLISM

In its carotenoid metabolism the garibaldi exhibits some interesting contrasts with most other animals so far investigated. While consuming diets containing ample quantities of both types of carotenoid, some animals (certain birds, numerous fishes, brittle-stars, mollusks, and others) exclusively select xanthophylls, whereas others (as the horse, at least one marine worm,

some sponges) select only carotenes. Certain animals, including man, frogs and octopi, assimilate all types of carotenoids from their diet. Still others, for example swine, goat, rodents, and other mammals, quantitatively reject or destroy all carotenoids. (Zechmeister, 1937; Fox, 1947; Crane, 1949.)

Several marine fishes studied in this laboratory have been observed to store no carotenes or acidogenic carotenoids, but only xanthophylls, chiefly of the taraxanthin class and only in the esterified condition. As examples, the shiner seaperch (*Cymatogaster aggregata*), the California killifish (*Fundulus parvipinnis*), and the California mudsucker, or long-jawed goby (*Gillichthys mirabilis*), are all carotene-free. When fed xanthophyll-free diets, these species have lost little or none of their skin xanthophylls during periods of several weeks. In recent experiments at Scripps Institution, by Arthur S. Lockley, *Gillichthys,* after longer maintenance on special diets, did lose some xanthophyll, but individuals on a carotene-rich diet lost less than did those deprived of carotenoids. The *Fundulus,* like *Hypsypops rubicunda,* sustains its supply of xanthophylls for periods of 90 days or more, even when fed a carotenoid-free diet (Sumner and Fox, 1935). *Fundulus* stores no dietary carotene as such, but seems able to convert it into integumentary xanthophyll. The opaleye (*Girella nigricans*) steadily loses its supply of xanthophylls when kept in laboratory aquaria (Fox, 1947). Various other fishes probably react similarly, for we have frequently noted that genera with rich yellow to red colors in nature, *Gibbonsia* for example, fade rather rapidly in captivity.

The assimilative specificity for dietary carotenoids remains an old and baffling enigma. But in *Hypsypops rubicunda* a new contingency has been revealed. For here is a species which, on a natural diet rich in both xanthophylls and carotenes, stores certain xanthophylls and quantitatively rejects carotenes (in nature, garibaldis feed chiefly but not exclusively on algae). Denied xanthophylls, but fed ample β-carotene in captivity, the fish absorbs small amounts of the carotene unchanged, while steadily losing integumentary xanthophylls. This feature of carotene assimilation presents additional complexities. A desirable extension of this study would involve the determination of whether or not the garibaldi might assimilate various xanthophylls and either store them as such or convert them into its own type of xanthophyll.

Summary

The garibaldi, *Hypsypops rubicunda* (Girard), passes through 3 distinct color phases. The young are very brilliantly marked with blue on an orange to red base. In color and also in quick-hiding habits they resemble, as though by recapitulation, the damselfishes of coral reefs. The metallic blue matches that of certain algae in the same habitat. The dusky, secretive half-grown appear to be protectively colored. The adults, largely free from predation, seem to use their brilliant orange color to advertise territorial occupation.

The relative quantity of carotenoid pigments in the skin increases markedly with age, very rapidly at first, and is subject to wide individual variation. There may be some geographical variation, but evidence on relation of xanthophyll content to temperature is conflicting. Persistence of xanthophyll in captivity varies greatly.

The integumentary carotenoids of the garibaldi are chiefly esters of one or more taraxanthin-like xanthophylls, also resembling dinoxanthin, and probably not identical with taraxanthin; with a smaller fraction similar to eloxanthin. Carotenes seem to be normally lacking.

Specimens long maintained on a carotenoid-free diet apparently lost some of the integumentary xanthophylls, as did others fed on this diet supplemented with carotene. On their skin pigments the experimentally fed fish did not differ from the controls except in one significant respect: small quantities of β-carotene were stored by fish fed on a diet rich in this biochrome. This is the first demonstration of the direct assimilation and storage of carotene by a fish of normal xanthophyll-assimilating, carotene-rejecting metabolic habit.

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Additional Oklahoma Fishes with Validation of *Poecilichthys parvipinnis* (Gilbert and Swain)[1]

By George A. Moore and Frank Bernard Cross

DURING the past two years collections of fishes from Oklahoma have yielded thirteen previously unrecorded species. Six of these—*Cycleptus elongatus, Moxostoma aureolum, Carassius auratus, Schilbeodes mollis, Poecilichthys jessiae,* and *P. cragini*—were included by Hubbs in a manuscript supplementary list of fishes known from adjacent regions and consequently to be expected in Oklahoma. *P. cragini* was taken in northeastern Oklahoma from the Grand (Neosho) River system. *Archosargus probatocephalus* is reported on the basis of specimens seen from the Arkansas and Red River systems. *Lepomis auritus, Perca flavescens, Menidia audens, Notropis atrocaudalis, Poecilichthys jessiae, P. parvipinnis,* and *Lepomis symmetricus* were taken exclusively in the Red River system, the last four only in southeastern Oklahoma. Notes on the various species follow.

The following abbreviations are used. OAM=Oklahoma Agricultural and Mechanical College; UOMZ=University of Oklahoma Museum of Zoology; UMMZ=University of Michigan Museum of Zoology; USNM=United States National Museum, and MCZ=Museum of Comparative Zoology.

Cycleptus elongatus (LeSueur). Three blue suckers (OAM 2073) were taken Feb. 28, 1948, by W. H. Thompson in a 1½-inch mesh gill net in Love County near the mouth of Hickory Creek in Lake Texoma, a large Red River impoundment completed in 1944. The length in millimeters followed by the weight in grams of each specimen is 365, 709; 370, 723; and 387, 735. Scale samples indicate that these fish belong to the 1946-year class and, therefore, must have been born above the dam. Collections made in May, 1948, from the Washita River, a Lake Texoma tributary, at Daugherty, failed to yield any blue suckers.

Two young *Cycleptus* (UOMZ 25815, 35.5 and 50 mm.) were seined by Thompson in Carey Bay, Grand Lake, June 17, 1948. George Harry informed us that a blue sucker was taken in southwestern Missouri in Elk River, which flows into Grand Lake in Delaware County, Oklahoma. Characters of the Oklahoma specimens are as follows: lateral line scales 48 in 1, 53 in 1, and 55 in 3; dorsal rays 30 in 2 and 31, 33, and 34 in 1 each; anal rays 5 in 1, 7 in 3, and 8 in 1. The upper lobe of the caudal fin in the young is devoid of pigment except at the border.

Moxostoma aureolum (LeSueur).—Eight young (OAM 1528, 31-44 mm.) of the northern redhorse were collected by Moore, July 12 and 13, 1946, from the Chikaskia River northeast of Tonkawa in Kay County. At that time the Chikaskia was an olive brown color with pH 8.4, temperature 30° C., and flowed over a bottom of sand and mud. The redhorse were taken

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near shore and from water 3 feet deep in a long, deep pool below a shaley riffle. A gravid female *aureolum* (OAM 2744, 296 mm.) was secured by Homer Buck, March 5, 1949, in the Chikaskia immediately below the Blackwell Lake dam northwest of Braman, Kay County. This specimen, whose ovaries weighed 111.5 grams after formalin fixation and contained 29,732 eggs, was seined from a strong current created by flow over the concrete dam following heavy rains. The water temperature was 12° C. We have also examined an uncatalogued specimen (186 mm.) sent to us by Gordon Hall. This halfgrown example was collected by W. H. Thompson in Carey Bay of Grand Lake, June 17, 1948. W. R. Taylor showed Moore some specimens in the University of Michigan Museum of Zoology from the Chikaskia in Kansas.

The following counts and measurements were taken on the Oklahoma specimens: scales in the lateral line 43 (41-44); principal dorsal rays 12 in 3 and 13 in 7; pelvic rays 9-9 in 8, 10-9 in 1, and 9-10 in 1; the eye is contained 1.36 (1.2-1.6) (2.1 and 2.8 in half grown and adult) times in the snout; the body depth is about equal to the head length (head 1.3 and 1.4 in depth in half grown and adult) and goes 3.8 (3.6-4.0) (3.1 and 4.0 in adult and half grown) times in the standard length; the depressed dorsal is contained 1.7 (in 5), 1.8 (in 3), and 1.9 and 2.0 (in the half grown and adult) times in the distance from the dorsal origin to the tip of the snout; and the dorsal base is contained 1.55 (1.3-1.7) times in the distance from the dorsal origin to the occiput. In the young, the scale spots utilized in Hubbs' (1930) key are not evident; in the adult and half grown the basal portion of the exposed surface of many scales is pigmented.

Carassius auratus Linnaeus.—A. P. Blair took two specimens (65 and 68 mm.) from gravel pits on State Highway 82 between Salina and Locust Grove, in Mayes County, July 8, 1948. The writers collected 80 goldfish (OAM 2406, 25-92 mm.) in three hauls of a 10-foot seine from a small, shallow natural lake in the Cimarron River drainage 1½ miles northwest of Perkins, Payne County, October 21, 1948. The lake was highly turbid, and the small section seined was devoid of vegetation. Goldfish seemed by far the most abundant species present, but *Ameiurus melas* (Rafinesque), *Lepomis cyanellus* Rafinesque, and *Cyprinus carpio* Linnaeus also were taken. No hybrids between the goldfish and carp were found. The color of the goldfish ranged from the dull wild type to bright orange.

We were quite surprised to find a large population of wild-type goldfish in South Carrizzo (Carrizo) Creek, T.5N. R.2E., on highway 64 east of Kenton, Cimarron County, May 28, 1949. Forty-five specimens (16-26 mm.) are catalogued OAM 3037. South Carrizzo Creek at the time of collection was in a normal spring stage, with pools of water 3 to 5 feet deep heavily vegetated with *Najas, Potamogeton, Scirpus, Chara, Polygonum,* and *Spirogyra* between rocky and sandy shallow riffles. The goldfish were associated with *Campostoma anomalum plumbeum* (Girard) and *Plancterus kansae* (Garman) the only other fishes taken.

Notropis atrocaudalis Evermann.—A single 47-mm. specimen (OAM 588) was collected April 18, 1947, by W. H. Irwin and B. P. Glass, from Lukfata Creek, a Little River tributary, 7 miles northeast of Idabel, McCur-

tain County. The fairly clear water flowed rapidly over a bottom of sand, rubble, and occasional boulders. Two more specimens (37-43 mm.), now in the University of Tulsa collections, were taken by Blair, April 15, 1949, from a small mud-bottom creek in a pine-oak flat 5 miles south of Idabel.

Hubbs and Ortenburger (1929) reported *N. heterolepis atrocaudalis* Evermann from the Arkansas River system in Arkansas and Oklahoma, but their specimens later proved to be an undescribed species now bearing the *nomen nudum Notropis amnis* Hubbs and Greene, a common form in the Poteau River in Oklahoma.

Characters of the Oklahoma *atrocaudalis* are: scales 5 to 6—34 to 35—4 to 5 with 13 or 14 rows before the dorsal; teeth 4–4; pelvics 8–8 or 8–9; pectorals 13–14 or 14–14; anal 7; the eye enters the snout 1.3 and the head 4.2 or 4.3 times; the standard length contains the head length 4.0 to 4.2 and the body depth 3.5 to 3.9 times; the body is slightly compressed, the depth over the curve being 1.8 to 1.9 times the greatest width; the dorsal origin is almost exactly midway between the tip of the snout and the end of the hypural and directly over the anterior end of the pelvic base; in outline the back is highest at the dorsal origin, being slightly convex along the nape and traversing an almost straight line from the dorsal origin to the caudal base; the mouth in lateral aspect is horizontal anteriorly, but decurves abruptly about halfway back, and is slightly overhung by the fleshy snout; a lateral band passes across the snout through the eye and terminates in a conspicuous elongate spot at the caudal base; the slightly decurved lateral line originates in the lateral band, curves below it, then rejoins the band at a point below the posterior end of the dorsal base; the dorsal scale borders are conspicuously marked with numerous tiny melanophores which fade out near the lateral band, giving the appearance of a white band above the lateral band; the ventrum is devoid of pigment except for a few melanophores along the anal base and along the midventral line of the caudal peduncle.

Schilbeodes mollis Hermann.—Only the confusing references of Meek (1893 and 1894), suggest the presence of the tadpole madtom in stream systems flowing through Oklahoma. He reported *Schilbeodes gyrinus* Mitchill (= *S. mollis*) from an Illinois River tributary in Arkansas, but omitted the species from a later paper covering the same collections.

On August 28, 1947, Moore took a single 23-mm. specimen (OAM 1380) from an oxbow lake at Poteau, LeFlore County. Presumably this is one of the lakes mentioned by Meek (1896), since it is on the outskirts of the present town and residents of Poteau attest that the lake is very old. At present it is deep and clear with emergent aquatic plants growing near the steep banks. The *mollis* was captured among the vegetation in waist-deep water.

A second specimen (OAM 2356, 40.4 mm.) was taken April 6, 1947, in Clear Boggy River, 6 miles south and one-half mile west of Ada, Pontotoc County. At the time of our collection the Clear Boggy ran 6 inches deep over the riffles and was somewhat turbid as a result of recent rains (visibility 6 or 8 inches). The pH was 8.4 and the temperature 15.5° C. The sand and gravel bottom was covered with debris. *Cladophora* was the only aquatic vegetation noted.

On April 18, 1948, A. P. Blair obtained a third specimen (54 mm., now deposited in the Tulsa University collections) from a slough along Little River 6 miles northeast of Idabel, McCurtain County.

These three specimens agree quite well with a series from Swan Creek, tributary to the Maumee River in Ohio, collected by Milton Trautman, Albert Perlmutter, and Moore, April 24, 1938, except in these particulars: the Oklahoma specimens have 15 (in 2) and 16 (in 1) anal rays, whereas the Ohio specimens have 13 (in 4) and 14 (in 2) rays; the head and eye are proportionately slightly shorter and the pectoral spines longer than in the Ohio specimens.

In August, 1948, Moore found *S. mollis* abundantly represented in Mountain Fork River near its confluence with Little River. An analysis of these specimens will appear in a subsequent paper.

Perca flavescens (Mitchill).—Yellow perch have been introduced into Oklahoma waters rather frequently over a period of at least 27 years, but at present they are known to occur only in Mountain Lake, 2½ miles north of Woodford, Carter County. According to Woodford residents, only one planting of yellow perch was made, in 1933, and natural reproduction has since been sufficient to enable frequent catches. Jefferson Fuller gave us one 3-year-old specimen (OAM 1796, 115 mm.) taken in September, 1947. Mountain Lake is deep and clear, and during the summer of 1947 D. D. Poole, in the service of the Oklahoma Game and Fish Department, found a thermocline at about 15 feet. Rooted aquatic plants grow near the steep, rocky banks.

Gordon Hall, a University of Oklahoma graduate, wrote us that there is a specimen of *Perca* in UOMZ catalogued in July, 1925, from the South Canadian River 3 miles west of Norman, Cleveland County. The specimen was identified by Hubbs and was doubtless considered by him as poor evidence of the occurrence of the species in Oklahoma, since this form was not included in his manuscript list.

A. D. Aldrich of the Oklahoma Game and Fish Department has informed us that he distributed *Perca* while employed by the U. S. Bureau of Fisheries in 1922 and 1923, chiefly in Oklahoma and Garfield counties. About 1927 he and John Murphree hatched eggs, brought from Iowa, at the Durant hatchery, Bryan County, and at Heavener, LeFlore County. None of these fish reproduced in the hatcheries and they were not known to have spawned in the wild. Aldrich's data also show that something in excess of 50,000 fingerling perch were brought from the Sand Hill Lakes near Valentine, Nebraska, and planted in Spavinaw Lake, Mayes County, in 1930. Although this stock never became well adapted and apparently perished by 1936, when drought conditions caused a low water level and abnormally high temperatures, hook-and-line catches were frequent during the intervening period. Some natural reproduction was indicated, since Aldrich found young in hatchery ponds at Mohawk Park near Tulsa for several seasons after 1930. These young perch must have been carried many miles through the aqueduct from Spavinaw Lake.

Poecilichthys jessiae Jordan and Brayton.—Four specimens (2 males and 2 females, one of each sex OAM 587 and UMMZ, 46–47 mm.) were

collected in a tributary of Little River 4 miles north of Broken Bow, McCurtain County, by Irwin and Glass, April 19, 1947. A. P. Blair took 2 specimens (34 and 36 mm.) April 18, 1948, and 3 April 15, 1949, from the same locality. All are now deposited in the Tulsa University collections.

The following data were taken from the OAM and the 1948 Tulsa specimens: pored scales in the lateral line 33 in 1, 37 in 1, 38 in 2, unpored scales 14 in 1, 16 in 1, 18 in 2; dorsal fin rays XI–12 in 3, X–13 in 1; anal fin rays II, 7 in 3, II, 8 in 1; the standard length contains the head length 3.3, the head depth 5.7—5.9, and the body depth 5.0—5.8 times; the head length contains the eye diameter 4.3—4.7, the snout length 4.2—4.6, and the distance from the preopercular margin to the tip of the snout 1.4—1.5 times.

A color description taken from fresh breeding specimens follows: in males the background color is light tan dorsolaterally, paler ventrolaterally. The sides are irregularly mottled with shiny black, which is intensified below the lateral line and which tends to form rows of spots similar to those of *P. spectabilis* Agassiz above the lateral line. Between the black spots are irregular red areas above and below the lateral line, concentrated on the sides of the belly and extending forward to the pectoral fins. The cheeks, chin, breast, and pelvic fins are suffused with green. The anal fin is basally bright green grading to clear toward the margin. The spinous dorsal bears vertically contiguous blue, red, and blue bands at its margin and a brick-red spot on each interradial membrane near the fin base. The soft dorsal is not banded and the red is confined to the interradial membranes. The caudal fin is basally suffused with light green overlain by a vertical row of 3 black spots. The caudal rays are outlined by melanophores which are concentrated in the crotches, the interradial membranes being otherwise clear. The ventrolateral surfaces of the caudal peduncle bear two light green areas extending from the posterior end of the anal base to the caudal base and upward to the black on the peduncle. The pectoral fins are pale yellow, and patches of the same color occur between the pectoral base and the operculum. The gill membranes lack bright colors but are finely dotted with melanophores. The mid-dorsal line is peculiarly marked with eight rather indistinct black saddles of which the most conspicuous are the first (at the spinous dorsal origin) and the fourth (at the end of the spinous dorsal base). The fifth and sixth saddles lie within the base of the soft dorsal and the seventh and eighth on the caudal peduncle. A black line extends forward from the eye through the nostril and across the premaxillary but does not connect with the one on the opposite side. Single black spots are evident at the upper margin of the orbit and behind the eye, and two similar spots lie below the eye. A black streak extends vertically from the lower margin of the eye to the gill membranes.

Females have a similar distribution of black pigment except that the dorsal saddles are less distinct, the gill membranes are practically unpigmented, and the black on the head is more intense. Red pigment does not develop on the sides, but appears in a narrow band through the middle of the spinous dorsal. The interradial membranes of the spinous dorsal also bear scattered melanophores which are concentrated at the fin base, but

the fin is clear in general aspect. Scattered melanophores give the soft dorsal, which is otherwise clear, a checkered appearance. The anal fin is quite clear. Green, blue, and yellow pigments do not develop.

Poecilichthys cragini (Gilbert).—The Arkansas River darter is now represented in Oklahoma by several collections as follows: 67 immature to small adults from an Elk River tributary 1 mile east of Turkey Ford, Delaware County—Moore, June 22, 1940; 1 adult from a gravel pit between Salina and Locust Groove—A. P. Blair, Oct. 25, 1948; 1 breeding male from Little Spring Creek (Grand River system) 4 miles south of Locust Grove, Mayes County—Blair, Feb. 12, 1949; 6 adults from the same place—Blair, March 3, 1949; 5 juveniles, also from Little Spring Creek—Moore, May 7, 1949.

The 1940 collection site has since been inundated by Grand Lake. When the *cragini* were taken, the lake water was backing up rapidly behind the newly-constructed dam and already had encroached within 100 yards of the spring which was the brook's source. The abundance of *cragini* inhabiting the gentle riffles probably was attributable to their retreat upstream before the advancing lake waters. Little Spring Creek, site of the last three collections, is a clear stream with a moderate current over a mud, gravel, and sand bed, and is abundantly supplied with quiet pools in which aquatic vegetation *(Ranunculus, Jussiaea, Potamogeton, Polygonum, Myriophyllum, Callitriche,* and *Radicula)* flourishes. The juvenile *cragini* were associated with *Poecilichthys punctulatus* Agassiz in these pools. It is interesting that no adults could be found May 7.

The average character values of the Oklahoma specimens are as follows, with limits of variation in parentheses: pored scales 14 (5–20, usually 11–17); total lateral-line scales 50 (44–57, usually 47–54); spinous dorsal IX (VIII–XI, most often IX); soft dorsal 12 (11–13, usually 11 or 12); and anal II,7 (II,5—II,8). The juvenile *cragini* (11.5—20.5 mm.) differ from *punctulatus* (common in the same habitat) of like size in fin-ray counts, in having a conspicuous black bar extending downward below the eye, a more robust form, a blunter, more decurved snout, a smaller mouth, more conspicuous bars on the caudal fin, and fewer black spots on the median dorsal line and ventrum.

The breeding male collected by Blair on February 12 exhibits spawning characteristics also noted by Dr. R. M. Bailey on specimens taken by Henry Hildebrand on January 1, 1949, 1.5 miles north of Fowler, Meade County, Kansas, and communicated to us as follows:

> Adult males have bright orange branchiostegal membranes and there is a blotch of the same color on the axillary surface of the pectoral fin near the base. From the base of the lower caudal rays forward to the posterior one-half or three-fifths of the belly, the ventral surface varies from bright yellow-orange to orange. Another point of particular interest is the presence of well-developed tubercles on the anal fin rays. Adult females lack orange pigment and have no tubercules.

Blair's specimen has tubercles also on the pelvics and on the orange-colored parts near the anal base and along the belly, where they present a beaded appearance. There is also a suggestion of orange on the dorsal and caudal

fins. The interradial membranes of all fins are swollen, especially near their bases, as though they had been injected with a liquid.

The disposition of specimens is as follows: Turkey Ford specimens, OAM 2382 and UMMZ 156667; 3 specimens from Blair's March 3 collection from Little Spring Creek, OAM 2664; May 7 Little Spring Creek juveniles, OAM 2992. The remainder are in the University of Tulsa collections.

Poecilichthys parvipinnis (Gilbert and Swain).—Five representatives of the darter described by Gilbert and Swain (in Gilbert, 1888) as *Etheostoma parvipinne* were collected by the writers in Gates Creek, Choctaw County, June 3, 1948. One additional specimen was taken by Carl Rigney from the Mountain Fork River, McCurtain County, August 22, 1948. This form was synonomized with *Etheostoma squamiceps* Jordan by Jordan and Evermann (1896: 1096) and again with *Claricola squamiceps* by Jordan, Evermann, and Clark (1930: 292).

TABLE I

COMPARISON OF *Poecilichthys parvipinnis* AND *P. squamiceps*

Averages are followed by extremes and data for the holotype of *parvipinnis* (examined by E. A. Lachner) are in italics

Character	*parvipinnis*	*squamiceps*
Scales		
total in lateral line	52.2 (49–57) *49*	47.3 (41–54)
pored	48.4 (44–52) *48*	32.1 (25–39)
unpored	3.7 (0–7) *1*	15.8 (9–28)
above lateral line	6.3 (6–7) *6*	6.1 (5–8)
below lateral line	8.5 (8–10) *9*	7.6 (7–10)
humeral scale	absent *absent*	conspicuous
Fins		
dorsal spines	IX or X (rarely VIII) *XI*	usually VIII (VIII–X)
soft dorsal rays	usually 10 (9–12) *10*	usually 13 (12–14)
anal spines	II (sometimes I) *II*	II
anal rays	usually 8 (7–9) *8*	usually 7 (6–8)
Infraorbital canal	complete (8–10 pores) *complete, 8? pores*	incomplete, pores 4–4 or 4–3
Head in length	3.4 (3.0–3.6) *3.74*	3.3 (2.8–3.4)
Eye in head	4.4 (3.8–4.8) *4.6*	5.1 (4.3–5.8)
Eye in snout	0.9 (0.7–1.0) *0.9*	1.1 (0.9–1.3)
Coloration		
spots on scales	often single spot on each scale; *traces?*	mottled, never with a single spot on each scale
lateral-line scales	largely without black pigment; *not different from other body scales*	with black pigment except on pores
caudal spots	3 or 4 in vertical series, one nearest median line most distinct; *indistinct*	3 distinct

Our examination of several series of the two forms failed to indicate intergradation, the several significant morphological differences remaining distinct in all specimens (see Table I). We therefore propose validation of the name *Poecilichthys parvipinnis* in confirmation of Hubbs and Black (1941: 9) who regarded it as valid.

Although our analysis of *parvipinnis* does not agree in all respects with the original description (Gilbert and Swain, 1888), a re-examination of the holotype (USNM 36716) by Dr. E. A. Lachner indicated that its characters do not differ from those exhibited by the series we examined (Table I).

The Mississippi, Texas, Oklahoma, and Arkansas records herein reported represent a very great extension of the known range from the type locality near Tuscaloosa, Alabama, in the Black Warrior River system. Apparently the species is nowhere abundant, the largest of the seven collections consisting of 5 specimens (Oklahoma). Efforts to determine its habitat in Gates Creek met with little success. Two were taken from quiet water over a rubble bottom and 3 from a moderate current over a sand and gravel bed. The latter, and perhaps also the former, were in proximity to restricted growths of filamentous algae. Although Gates Creek is a spring-fed stream (as was the type locality), and was very clear at the time of our collection, it is of rather low gradient and obviously floods and becomes muddy at frequent intervals.

The specimens of *P. squamiceps* we examined show some interesting variations, particularly in regard to dorsal fin counts. All 13 specimens from Bedford County, Tennessee, have 8 dorsal spines and 12 (in 4) or 13 (in 9) soft rays, whereas in all other specimens the dorsal spines are usually 9 (rarely 8 or 10) and the soft rays usually 14 (sometimes 12 or 13). Furthermore, the Bedford County series show smaller scales and fewer lateral-line pores.

MATERIAL EXAMINED:

Poecilichthys parvipinnis.—UMMZ 146654, 4 specimens 23.6—39.6 mm., collected in Salt Spring near Tombigbee River, Clarke Co., Ala., Aug. 13, 1942, by George C. Moore. UMMZ 127843, 1 specimen 28.5 mm., collected in Caney Cr., Lincoln Co., Ark., June 20, 1939, by J. D. and R. V. Black. UMMZ 147542, 2 specimens 27.6—38.0 mm., collected in a small tributary to the San Jacinto River 5 mi. south of Conroe, Montgomery Co., Texas, Oct. 7, 1946, by Kirby H. Walker. UMMZ 154346, 3 specimens 30.5—46.7 mm., *ibid.*, May 2, 1948, by Kirby H. Walker, UMMZ 113867 3 specimens 27.8—30.0 mm., collected in Ponta Cr., Lauderdale Co., Miss., June 3, 1932, by Ameel and Hedrick. UMMZ 145060 (2 specimens) and OAM 2182 (3 specimens) 25.7—32.5 mm. collected in Gates Cr. (tributary to Kiamichi R.), at Fort Towson, Choctaw Co., Okla., May 29 and June 3, 1948, by George A. Moore and Frank B. Cross. OAM 2898 1 specimen 36.0 mm., collected in Mountain Fork River near its confluence with Little River, McCurtain Co., Okla., Aug. 22, 1948, by Carl C. Rigney.

Poecilichthys squamiceps.—UMMZ 122900, 5 specimens, 32.5—43.7 mm., collected in Mallard Creek (Tributary to Wheeler Reservoir on Tennessee River), Ala., Nov. 23, 1938, by Tarzwell and Qualls. UMMZ 121137, 13 specimens 35.5—56.5 mm., collected in Bennett Branch, Bedford Co., Tenn., April 7, 1937, Lawrence F. Miller. UMMZ 104243, 6 specimens 34.0—45.5 mm., collected in Harris Springs Pond, Wheeler Reservoir, Ala., May 26, 1937, by Cahn, Bryan and Miller. UMMZ 96363 and OAM 2183, 2 specimens 43.0—52.0 mm., collected in a tributary of Stone River, Tenn., June 26, 1928, by Becker. MCZ 24545, 2 specimens 45.4—48.0 mm., collected at Lebanon, Wilson Co., Tenn. (Cumberland River system), date and collector unknown.

Lepomis symmetricus Forbes.—A single specimen (OAM 2161, 37.5 mm.) was taken by the writers on June 2, 1948, from a swamp in the Mountain Fork drainage 3 miles south of Eagletown, McCurtain County. Thick growths of sedges, rushes, *Sagittaria*, and *Polygonum* surrounded cypress knees within the swamp, and willows, gum, and cypress grew abundantly along the bank. A cultivated field bordered the swamp.

The specimen has the following characteristics: dorsal X, 9; anal III, 10; head 2.4 in standard length; depth 2 in standard length; eye 3.8 in head; the length of the maxillary equals the distance from the snout to the center of the eye. The lateral line is incomplete, with 15 pored scales anteriorly followed by 11 unpored, 5 pored, and a terminal unpored scale (left side); right side similar, but with only 2 widely separated pored scales on the caudal peduncle. The posterior soft dorsal was basally red in life.

Lepomis auritus (Linnaeus).—Four yellowbelly sunfish (OAM 2075) were presented by W. H. Thompson, who obtained them from Louis Pickett of Duncan, Oklahoma. Pickett stated (personal communication) that he acquired 11 *auritus* March 26, 1941, from Mr. Minnix, Superintendent of the Texas State Fish Hatchery at Dundee, who had in turn obtained his stock from a hatchery near Austin, Texas. Pickett has raised 3 to 8000 fingerlings a year, all of which have been released in Lake Duncan, Stephens County. He states that they do not become so numerous as redear sunfish and bluegills but exceed the latter in size. The largest specimen herein reported weighed one pound after formalin fixation.

Menidia audens Hay.—Three specimens (OAM 2948, 42–49 mm.) were taken by Moore and class from barpits filled with overflow water of the Red River, in Bryan County, on Highway 299 south of Yuba, April 15, 1949. Although these specimens differ in some respects from the Arkansas specimens (Gosline, 1948), they agree more closely with *audens* than with *beryllina* as characterized by Gosline. Distribution also would indicate reference to *audens*. The following counts and measurements were taken from the Oklahoma specimens: body depth as per cent of standard length 16.6 in 1, 17.3 in 2; scales 40 in 2, 41 in 1; anal soft rays 15 in 1, 16 in 2; dorsal IV–1, 9 in 2, V–1, 9 in 1; predorsal scales 19 in 3. These specimens extend the known range about 180 airline miles westward up the Red River, assuming that the specimens referred to by Gosline are from southwestern Arkansas.

Archosargus probatocephalus (Walbaum).—A specimen was exhibited at a local hardware store by Dick Wiar, of the Ensign Supply Company, Oklahoma City, who stated that this fish was taken from a lake at Poteau, LeFlore County, during rough fish seining operations, and that others have been seen by Poteau residents. This specimen was interpreted as a possible result of a prank, but reports of occurrences from other localities in the state lend credence to the Poteau record. Furthermore, Gunter (1942: 315) stated that Carr found this species widely distributed in freshwater of southern peninsular Florida.

Another specimen taken by a crappie fisherman from Lake Lawtonka, Comanche County, in September, 1948, was presented to us by A. D. Aldrich, who secured it from Mr. J. A. Manning, superintendent of the Medicine Park State Fish Hatchery. Manning informed us (personal communication) that this specimen weighed 2 pounds and that a 12-pound specimen was caught by an angler 4 miles southeast of Lawton in Cache Creek. He testifies strongly to the authenticity of the records.

The following notes were taken from the Poteau and the Lake Lawtonka specimens (the latter in parentheses): upper incisors 6 (6); lower incisors 7 with one apparently missing (8); upper molars in 3 rows on each side,

the inner row including the largest teeth (both specimens); lower molars in two rows on each side (both specimens); cheek scales in 5 (6) rows; eye 4.3 (4.0) and interorbital width 2.5 (2.2) in the distance from the snout to the preopercular margin.

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Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

Ichthyological Notes

THE STATUS OF THE AMERICAN MULLETS, *MUGIL BRASILIENSIS* AND *M. CUREMA*.—I am informed in a letter from Dr. Otto Schindler, of the museum at Munich, that the types of *Mugil brasiliensis* Agassiz (in Spix and Agassiz, 1829) were destroyed with the whole fish collection of that museum in a bombing attack in April, 1944. I propose that the name *M. brasiliensis* now cease to be used, for the following reasons.

The original description begins "Pinna dorsali posteriore, caudali et anali squamulis minutissimis obtectis," and the anal fin is stated to have 14 rays. It is therefore surprising to find *M. brasiliensis* in Jordan and Evermann's "Fishes of North and Middle America" (1896: 810) in the section of the key distinguished by "soft dorsal and anal fins almost naked; anal rays III 8, rarely III 7," with *M. liza* Val. as one of its synonyms. Current American works adopt this usage (for example, Schultz, 1949, Proc. U. S. Nat. Mus., 99: 114). On the other hand Günther (Cat. Fish. 3: 431) used the name for a species with scaly dorsal and anal fins, although with III 9 as its anal fin formula, and considered *M. curema* Val. a synonym, as did Valenciennes also (C.V., 11: 88).

In 1884, Jordan and Swain (Proc. U.S. Nat. Mus. 7: 269) had taken a different view as a result of a report received from Dr. A. Spangenberg, then curator of the museum at Munich. This report gave the length of the largest specimen, a stuffed skin, as 400 mm. and the number of its scales in longitudinal series as 32. The anal rays could not be counted. Dr. Spangenberg regarded this specimen as the basis of the figure in Spix and Agassiz. It is clear that we shall never know what it was. The smaller spirit specimens both had III 9 anal rays. In one the scales numbered 35, the distance between the end of the pectoral fin and the level of the origin of the dorsal was one-third of the length of the pectoral and the teeth were very small. In the other the corresponding numbers were 38 or 39, and one-twelfth, and the teeth were larger. Jordan and Swain reserved judgment on the spirit specimens, regarded the stuffed specimen as the type and identified it with *M. trichodon* Poey, a species with broad adipose lids, densely scaled soft dorsal and anal fins, 33 scales in a longitudinal series, and A III 8.

Although Jordan and Evermann in 1896 may well have considered this an unsatisfactory conclusion, there seems still less cause for satisfaction with their decision of that date. The types of *M. curema* and *M. liza* still exist in good condition in Paris, where I examined them last year by courtesy of Prof. L. Bertin. *M. curema* is probably the species which now goes by that name in American literature. Valenciennes had more than one species represented in his material of "*M. liza*" and it may be possible to use the name for the "*M. brasiliensis*" of Jordan and Evermann. This last question will be dealt with more fully elsewhere by one of my colleagues.—ETHELWYNN TREWAVAS, *British Museum (Natural History), London, S.W. 7, England.*

AN ALBINISTIC *ICTALURUS CATUS* FROM FLORIDA.—Mr. Bert Schultz of Winter Haven, Florida, recently sent me a catfish taken during the summer of 1947 on a trot-line in Lake Jessie, Polk County, Florida. A notation on the data sheet states that this specimen was "golden" in life. It had been preserved in strong formalin while still alive and most of the mucous had separated from the body when I received it. It proved to be an adult *Ictalurus catus* (Linnaeus). It is now a creamy white color with no trace of pigment except for the eyes, which are dark and may contain some chromatophores. In all respects except coloration this specimen appears normal. It is a gravid female with ripe ova in the ovaries, 210 mm. standard length, and weighs 193 grams.—WILLIAM M. MCLANE, *Department of Biology, University of Florida, Gainesville, Florida.*

THE BLOOD-CLOTTING TIME IN SPENT SILVER SALMON, *ONCORHYNCHUS KISUTCH* (WALBAUM).—Studies of fish hematology have been complicated by the extremely rapid clotting of the blood. This almost instantaneous clotting, designed to protect the fish from fatal hemorrhage following slight injury, has compelled many to use anti-coagulants in order to collect suitable samples.

While observing spawned out silver salmon at the hatchery on Soos Creek, near Auburn, King County, Washington, we were impressed by the extremely slow clotting of the blood of these fish. Determinations of the clotting time were made by the capillary tube method. Blood was collected in the glass capillaries from the caudal artery which was exposed by slashing off the caudal fin.

TABLE I

BLOOD-CLOTTING TIMES OF SEVEN SPENT SILVER SALMON

(Water temperature and fish body temperature, 4°C)

Sex of fish	pH of blood (Electrometric)	Clotting time (Minutes and seconds)	Remarks
Male	7.09	3:10	In good condition
Male	7.62	2:30 and 4:10	Poor condition
Male	7.35	3:00	Almost dead
Female	7.60	2:40	Full of ova in good condition, but fish almost dead
Male	7.40	Over 5:20	Much skin abrasion, in very poor condition
Male	7.39	4:20	Fairly good condition
Male	7.54	Over 13 minutes	Very poor condition

The clotting time in these spent fish, Table I, varied from two and one-half minutes to over thirteen minutes. The clotting time of actively feeding silver salmon, on the other hand, has been estimated by us to be less than ten seconds. No correlation could be observed between the blood pH, condition of the fish, and clotting time. It was noted, however, that the fish with the shortest clotting time was a female that was dying without having deposited her eggs. This may indicate that the increase in clotting time is one of the several physiological and morphological changes that inevitably cause the death after spawning of all salmon belonging to the genus *Oncorhynchus*. The persistence of eggs in this female may have inhibited the breakdown of the clotting mechanism to some extent.

Examinations of stained blood smears from the above fish indicate that the slow clotting time is due to some change in the blood chemistry. Thrombocytes were common in the blood of these fish but did not show any evidence of dissolution. These cells, which are analogous to the blood platelets in mammalian blood, when seen in blood smears prepared from actively feeding and growing fish are always in the process of dissolution with only shreds of cytoplasm adhering to the nucleus. In these spawnouts, however, the thrombocytes are seen with their cytoplasm intact. The failure of the thrombocytes to break down in these spent fish suggests the inhibition or absence of some substance which normally releases the thromboplastin from the thrombocytes. Elucidation of the observed phenomena is beyond the present scope of our study and will be left to students of blood chemistry.—MAX KATZ and MORRIS SOUTHWARD, *Environmental Health Center, U. S. Public Health Service, Cincinnati, Ohio,* and *School of Fisheries, University of Washington, Seattle, Washington.*

CORRECTION FOR "A REVISION OF SIX SUBFAMILIES OF ATHERINE FISHES, WITH DESCRIPTIONS OF NEW GENERA AND SPECIES."—Dr. George S. Myers has called to my attention certain nomenclatorial matters that I wish to correct in my recent publication (Proc. U. S. Nat. Mus., 98, 1949: 1–48, figs. 1–9, pls. 1, 2). Since *Tropidostethus* Ogilby, 1895, is preoccupied, and a new name is necessary, I propose **Tropidostethops,** new generic name to replace *Tropidostethus* Ogilby, with the same genotype—*Tropidostethus rhothophilus* Ogilby, 1895. Since *Tropidostethus* was used by me as the stem of the subfamily name, and is no longer available, I herewith substitute **Notocheirinae,** new subfamily name based on *Notocheirus* Clark. The subfamily name based on *Taeniomebras* Ogilby should have been spelled Taeniomembradinae.—LEONARD P. SCHULTZ, *U.S. National Museum, Washington 25, D.C.*

Herpetological Notes

A CASE OF *HELODERMA* POISONING.—On June 15, 1948, I had the opportunity to witness a bite by the Gila monster, *Heloderma suspectum*. The incident took place in the Dayton Public Library Museum, where Maurice Fitzmaurice was handling a 15-inch specimen that had recently been received from Tucson, Arizona. Fitzmaurice was reaching past the lizard to the water dish in the cage, when without warning the lizard quickly turned and seized part of the middle and distal phalanges of his right forefinger. Holding on tightly it chewed slowly, working its teeth deeper into the flesh.

I tried to pry open the lizard's mouth with a mechanical pencil, but to no avail. Finally a full five minutes after the bite occurred, Fitzmaurice slammed the lizard to the floor and pried at its mouth with his left thumb. The lizard momentarily opened its mouth, and the victim withdrew his finger. He was immediately bitten on the left thumb, but was almost instantly released.

In the meantime Fitzmaurice's finger had begun to pain him. He held his hand under running water for a few minutes in an attempt to wash away the saliva and possible venom. There was slight bleeding from the four punctures in his right forefinger and the two in his left thumb. By now the forefinger was beginning to swell, and he experienced considerable pain in his whole right hand.

We walked to a doctor's office three city blocks away but were unable to obtain help. By now the forefinger and much of his right hand as well as his left thumb had become decidedly swollen. The punctures were still bleeding, and throbbing pains had commenced in his right hand. There were distinct signs of nervousness and shortness of breath. A police car was called and at 5:00 P.M., just thirty minutes after the bite occurred, we reached the hospital. Occasional pains were felt in the right arm, and the pain in the right hand and forefinger had become intense.

At 5:15 P.M. the following treatment was given at the Miami Valley Hospital: the wounds were cleaned, and 1/6 grain of Morphine Sulphate was injected hypodermically into the *thenar eminence* of the right hand. When the morphine had taken effect, the punctures were lanced. One of the teeth had punctured the nail of the forefinger. This was split so that the wound could bleed freely. All of the wounds were treated with an antiseptic. Six times during the next twelve hours 50,000 units of Penicillin were injected intramuscularly.

Fitzmaurice was released from the hospital on the following morning. At that time the dorsum of his hand was only slightly swollen, and he did not complain of any pain.

I wish to thank Miss Sally M. Kuniewicz, R.R.L., Medical Records Librarian at the Miami Valley Hospital, for her assistance in obtaining the hospital records on the case.
—WILLIAM E. DUELLMAN, *436 Greenmount Blvd., Dayton 9, Ohio.*

BACHIA TRIDACTYLA (DAUDIN, 1802), REPLACED BY *BACHIA SCHLEGELI* (DUMÉRIL AND BIBRON, 1839).—Laurenti (1768, Syn. Rept.: 64) described a new species of lizard under the name *Chalcides tridactyla*. This species was later placed by Boulenger (1887, Cat. Liz., 3: 403) in the family Scincidae as *Chalcides tridactylus*.

Daudin (1802, Hist. Nat. Rept., 4: 333, pl. 57) presented Laurenti's species as *Seps tridactylus*, using the name *Chalcides tridactylus* for a new species (*ibid.*: 367, pl. 58, fig. 3). This subsequently was placed in the family Teiidae as *Bachia tridactyla* (Burt and Burt, 1933, Trans. Acad. Sci. St. Louis, 28: 57).

Chalcides tridactylus Daudin is evidently a homonym of *Chalcides tridactyla* Laurenti and as such must be rejected, according to Art. 35 of the Règles Internationales de la Nomenclature Zoologique.

The oldest available synonym for Daudin's species is *Chalcides schlegeli* Duméril and Bibron, 1839 (Erp. Gen., 5: 457).

Accordingly, *Bachia schlegeli* (Duméril and Bibron, 1839) is the name to be given to the species originally described by Daudin as *Chalcides tridactylus* (not of Laurenti).—P. E. VANZOLINI, *Dept. Zoologia, São Paulo, Brasil.*

NOTE ON OKLAHOMA MICROHYLID FROGS.—Hecht and Matalas (1946, Amer. Mus. Novitates, 1315: 1–21) found apparent intergrades between *Microhyla carolinensis* and *M. olivacea* in several localities, including Latimer County, Oklahoma, and reduced the two forms to subspecific status. The present findings neither confirm nor reject such an allocation but seem pertinent toward eventual understanding of the relationship of these frogs.

A comparison of specimens of *olivacea* from the vicinity of Locust Grove, Mayes County, Oklahoma, with specimens of *carolinensis* from near Oaks, Cherokee County, Oklahoma, reveals no indication of intergradation. None of the specimens from the first locality can possibly be confused with any of the specimens from the second locality. In the series of *olivacea* the dorsum is olive, in the *carolinensis* it is brown; in the former the venter is immaculate, in the latter it is mottled. It is also to be noted that the specimens of *carolinensis* average considerably larger than those of *olivacea*.

The zone of intergradation, if such there be, must be remarkably narrow, since the two localities in question are but 15 miles apart. Difference in ecological requirements would not seem to be important in separating the two forms in the region of contact. I have collected *olivacea* in many diverse ecological situations including hills, prairies, and flood plains. In northeastern Oklahoma *carolinensis* occurs not only in woodland situations but in the small prairie areas which are not uncommon in this part of the Ozark uplift.

On the night of May 20, 1949, following a very heavy rain, breeding adults of *carolinensis* were collected near Oaks and breeding adults of *olivacea* near Tulsa. Five hybridizations of ♀ *carolinensis* × ♂ *olivacea* and three of ♀ *olivacea* × ♂ *carolinensis* were made. Males of *carolinensis* were reluctant to clasp the smaller females of *olivacea* and in two crosses it was necessary to squeeze eggs into a sperm suspension. In four of the five hybridizations of ♀ *carolinensis* × ♂ *olivacea* and the cross of ♀ *olivacea* × ♂ *carolinensis* in which clasping was achieved, virtually 100 per cent of the eggs cleaved and developed into apparently normal larvae. In the other crosses the percentage of fertilization was somewhat lower. Difficulty was experienced in rearing the larvae, and, although some survived for approximately 90 days, none metamorphosed. This is believed to be due to improper food or environment rather than to any inherent incompatibility of germ plasms.

It is conceivable that the relationship of *carolinensis* and *olivacea* is similar to that of *Bufo woodhousii* and *B. fowleri* (Blair, 1941, Genetics, 26: 398–417; 1942, Biol. Symposia, 6: 235–249), in which hybridization apparently takes place at some points of contact and not at others. The reluctance of males of *carolinensis* to clasp smaller females of *olivacea* would seem to constitute an incomplete isolating mechanism. Another such rudimentary isolating mechanism is the fact that *olivacea* is more dependent upon rainfall for breeding activity than is *carolinensis*.—ALBERT P. BLAIR, *Department of Zoology, University of Tulsa, Tulsa, Oklahoma.*

BIRDS AS BULLFROG FOOD.—The American bullfrog (*Rana catesbeiana*) is known to catch and eat small birds at times (Frost, 1935, COPEIA, 1935: 15–17), but rarely has a frog been seen in the act. Mr. Fred D. Douthitt, Superintendent of the San Joaquin Experimental Range, has a garden pool about 10 feet in diameter near the porch of his residence. Birds of various species commonly visit the pool to drink and bathe. A bullfrog living in the pool has occasionally made unsuccessful efforts to catch birds by springing at them from behind the shelter of a pond-lily leaf. On July 13, 1949, shortly after 6:00 P.M. Mr. Douthitt and Jay R. Bentley saw the bullfrog just after it had caught a brown towhee (*Pipilo fuscus carolae*) by one foot or leg. The frog then submerged to drown the bird, which it did after several attempts amid frantic wing flapping by the towhee. Swallowing the bird required nearly an hour, and most of this time was needed to engulf the last of the towhee's long tail feathers. About two hours later the bullfrog was croaking again.

An adult bullfrog was collected near Sacramento on August 21, 1938, and when dissected found to contain a yellow-throat (*Geothlypis*).—WALTER E. HOWARD, *Division of Zoology, University of California, Davis, California.*

SIZE RANGE IN ADULTS OF THE TOAD *BUFO COGNATUS*.[1]—If only one measurement is to be made upon which to judge size in *Bufo*, perhaps snout-vent length is as good as any and definitely superior to some that might be chosen. I present herewith measurements taken as a routine on many adult specimens of *Bufo cognatus* Say, incidental to work on other problems. For the purpose of this paper, I take as adult those males with fully developed gular pouches and/or those that give the quack-like protesting note when handled and those females that have developed a rounded body (at small sizes), or that have well developed ovaries (if borderline cases). Any female above 75 mm. is adult. Table I summarizes the data for 702 toads, of which 552 are males and 150 females, all collected by me and associates (principally Dr. C. C. Smith) in Oklahoma between 1939 and 1947. The largest series (443 males and 112 females) was taken in Cleveland County; the remainder are from scattered areas in the prairies. Some were measured while alive, others after preservation in 65–70 per cent ethyl alcohol. These series are tabulated separately, but item 5 combines all males and item 10 all females.

Measurements were made by flattening the toad in the left hand and measuring along the back to the nearest mm. with a metric rule. Many measurements were made in the field and I found this method better than use of calipers or dividers on live struggling animals. The same method was used for the preserved specimens in order to secure comparable data. Tests by repeated measurement of single individuals indicated an accuracy within 1–1½ mm. Means are expressed to the nearest 0.1 mm. with standard error to three decimal places.

Wright and Wright (1949, Handbook of Frogs and Toads, 3rd. ed.) give the lengths of adults of this species as 47–95 mm. (males) and 60–99 mm. (females). No statement is made as to how many measurements these figures represent. Smith (1934, Amer. Midl. Nat. 15: 377–528) reports 4 adult males from Kansas as 44.6–83.3 mm., and 4 females as 82-1–114.0 mm. Bragg (1940, Amer. Nat., 74: 322–349 and 424–438) found that 35 males, calling when collected in Cleveland County, Oklahoma, measured (preserved) 72–90 mm., with mean a small fraction above 80. These seem to be the principal figures previously published.

As implied in the above figures, males tend to be smaller than females but Table I shows 396 males to have the same mean snout-vent length as the mean of the combined total of the 702 specimens (including both sexes) from Oklahoma (80.8 mm., not given in the table). Females, however, exceed males in my figures by 5.0 mm. as a difference in mean values. The apparent discrepancy is due in part to a greater range in female size (49–112 mm.) than in male size (63–103), in part to difference in the sexes collected in the different size groups (there are both more large and more small females than males in the sample), and perhaps in part to differential collecting. The last is possible, since at some seasons females are more active in feeding than are males.

TABLE I

Mean (M), Mode (MO) and Range (R) values for 702 adults of *Bufo cognatus* from Oklahoma. For summary data see item 5 for males, 10 for females.

Item	N	MO	R	M	Group	Sex	Alive or Preserved
1	47	70	65– 90	74.6 ± 0.548 –	Cleveland County	Male	Preserved
2	109	82	63– 95	77.9 ± 1.052 +	Oklahoma not Cleveland County	Male	Preserved
3	156	82	63– 95	76.9 ± 0.399 +	Total Oklahoma	Male	Preserved
4	396	80	63–103	80.8 ± 0.329 +	Cleveland County	Male	Alive
5	552	80	63–103	79.8 ± 0.261 –	Total Oklahoma	Male	Combined
6	30	79	62–110	84.8 ± 2.173 –	Cleveland County	Female	Preserved
7	38	80	70–110	88.0 ± 1.844 +	Oklahoma not Cleveland County	Female	Preserved
8	68	80	62–110	86.5 ± 1.409 +	Total Oklahoma	Female	Preserved
9	82	86	49–112	85.9 ± 1.259 –	Cleveland County	Female	Alive
10	150	80	49–112	84.8 ± 0.939 –	Total Oklahoma	Female	Combined

We may summarize by the following, taking into account data already in the literature. In *Bufo cognatus* adults:

[1] Contribution from the Department of Zoological Sciences and the Oklahoma Biological Survey, University of Oklahoma, Norman.

(1) Females potentially reach a larger size than males.
(2) In some populations, at least, an occasional very small female occurs.
(3) Some males exceed some females in size.
(4) The known limits for specimens from Oklahoma are (a) males, 63–103 mm.; (b) females, 49–112 mm.
(5) The known limits for the species are (a) males, 44.6–103 mm.; (b) females, 49–114 mm. It is of course possible that these limits may be exceeded in nature, particularly the upper one.

ARTHUR N. BRAGG, *University of Oklahoma, Norman, Oklahoma.*

PSEUDACRIS NIGRITA TRISERIATA ON THE NORTH SHORE OF LAKE SUPERIOR.—Breckenridge (1944, Reptiles and Amphibians of Minnesota: 67) states that the swamp tree frog, *Pseudacris nigrita triseriata* (Wied), occurs "throughout Minnesota, with the possible exception of the extreme northeastern corner." He includes no records for Lake or Cook counties, north of Lake Superior. In late June, 1948, *Pseudacris* was found to be breeding abundantly along the shore of Lake Superior wherever I made examinations. Two males were collected at Grand Marais, in Cook County. Another male was collected at Little Marais, in Lake County. The first 2 had the following measurements (in mm.): 24-34-10 and 23-33-9.5 (body length—hind leg—tibia length). The Little Marais specimen measured 25-34-10 mm. These specimens are now in the State Teachers College collection in Mankato, Minnesota, together with materials from Nicollet and Blue Earth counties. The northern individuals are, to me, indistinguishable from those taken in the southern part of the state, but one of the northern specimens has an unusually interrupted dorsal pattern that consists of numerous irregular dark splotches on a light background, not at all suggestive of the more typical series of 5 irregular longitudinal stripes.

The north shore of Lake Superior is formed of rugged Archean rocks, which rise abruptly from the water's edge. *Pseudacris* could be heard calling both day and night from the water-filled depressions in the rocks. Some of these rocky pools were only a few feet above the lake whereas others were 50 feet or more above the water; some received a rather constant supply of water by seepage from springs or swamps whereas others were dependent on occasional high waves or on rain to keep them filled; and some were almost completely bare with only a few tiny crevices whereas others were thickly strewn with rock fragments that afforded concealment for the vocalists. The pools ranged in depth from a few inches to about 2 feet and in diameter from less than 3 feet to more than 20 feet. These clear pools essentially free of vascular plants contrast sharply with the vegetation-choked ponds that form the more usual breeding habitat of this frog.

The larger pools were well populated with *Pseudacris* tadpoles that ranged from slightly over a centimeter to 34 mm. in length, indicating a rather extended breeding season. The species may begin breeding in early March before the ice has completely left even the shallowest ponds but along the north shore of Lake Superior it probably does not leave hibernation before April. Breckenridge (1944) has estimated the egg and tadpole stages of this frog to be about 8 to 10 weeks long in Minnesota. Since some of the tadpoles were about to metamorphose during the last week in June, the first successful spawning probably occurred during the middle of April. A dry spell set in late in May that lasted through the first three weeks of June and then was broken by several days of torrential rains. Afer their long silence the swamp tree frogs returned to the pools with the rains and once more began calling. Two days after the rains started I found clusters of fresh eggs. All the eggs located were in small recently filled depressions that were free of tadpoles. That all except the largest and deepest pools had dried completely during early June was clearly shown by the fact that only these depressions contained tadpoles and heavy growths of green algae.

No other species of amphibian was found in these pools, but the wood frog (*Rana sylvatica* Le Conte) and the green frog (*Rana clamitans* Latreille) were common in the swamps a short distance back from the shore.—DON L. JACOBS, *Department of Botany, University of Georgia, Athens, Georgia.*

THE STATUS OF THE FLORIDA BROWN SNAKE, *STORERIA VICTA*.—In his revision of the genus *Storeria*, Trapido states: "I find no evidence . . . that *S. victa* intergrades with any of the forms of [*S.*] *dekayi*" (1944, Amer. Midl. Nat., 31: 40). It is evident that if *S. dekayi* and *S. victa* intergrade, they must do so in the lower Coastal Plain of Georgia. Trapido had only two *dekayi* and two *victa* from the Georgia Coastal Plain. He further states of *victa* that "the northern limit of its range now overlaps that of *S. dekayi*" (*op cit.*: 44), but presents no evidence in support of this statement. His maps and accounts of distribution suggest that *dekayi* inhabits all of Georgia except the extreme southeastern portion, and reaches Florida only in the Panhandle; and that *victa* inhabits all of Florida except the Panhandle, and invades Georgia only in the extreme southeastern portion. Obviously the situation calls for further study.

Many years of collecting in Georgia have revealed the presence of two forms of DeKay's snake in that state. The first of these is relatively large and stout, pale gray or greenish-gray in color, with a pattern of dark tessellations, which often cross the mid-line of the back, and with 17 scale rows. The second form is relatively small and slender, grayish-brown or dull brown in color, generally without dark tessellations but with a pale vertebral stripe bordered by blackish spots that fuse across the mid-line in a few examples, and with scales usually in 17 but occasionally in 15 rows. The first form occupies all the region above the Fall Line, and much of the relatively high western portion of the Georgia Coastal Plain; the second occupies the eastern portion of the Coastal Plain, and also occurs in adjacent areas of South Carolina. The geographic segregation of the two is not perfect, the first occurring, albeit rarely, in the upper and middle portion of the east Georgia Coastal Plain. Where the two forms overlap, they are separated ecologically, the first being found in meadows and forests, and the second confined to river swamps and creek bottomlands. Specimens intermediate between the two forms are often encountered in the area of overlap.

The first form is the snake that Trapido calls *S. dekayi wrightorum* (*op. cit.*: 57); the second obviously bridges the gap between *wrightorum* and *victa*.

In the upper Coastal Plain, specimens of the *victa*-like form with only 15 scale rows are very rare; I have collected but one such in the Fall Line area, in the Savannah River swamp between Beech Island and Kathwood, Aiken County, South Carolina. This locality has yielded 18 other specimens, all displaying the *victa*-like coloration, pattern, and form, but with 17 scale rows. A few miles to the north, at North Augusta, Aiken County, and across the Savannah River in the vicinity of Augusta, Richmond County, Georgia, only *wrightorum* occurs; over 200 specimens have been examined. Seven *victa*-like specimens, all with 17 scale rows, were taken in McBean Creek swamp near McBean, Richmond County, Georgia, a locality about 15 miles below the Fall Line. A *victa*-like specimen with 15 scale rows was taken at Shell Bluff Landing, Burke County, Georgia, about 25 miles below the Fall Line; a very similar specimen, but with 17 scale rows, was taken about 2 miles farther south. In northern Emanuel County, Georgia, about 40 miles below the Fall Line, two snakes fairly typical of *S. d. wrightorum* were taken in a relatively dry wooded area, while along the bottomlands of the Ogeechee River in the same region were taken 7 *victa*-like specimens, 2 with but 15 scale rows. About 130 miles below the Fall Line, along Suwanoochee Creek, Clinch County, Georgia, 5 *victa*-like snakes were taken, 4 with but 15 scale rows. The *victa*-like form occurs in the Okefenokee Swamp on Billy's Island, Charlton County, Georgia. Trapido lists 2 specimens from this locality as *S. victa* (*op. cit.*: 44),[1] while Wright and Bihsop considered the specimens to be merely *S. dekayi* with but 15 scale rows (1915, Proc. Acad. Nat. Sci. Phila., 67, 1: 177). I have not seen these specimens; however, Wright and Bishop's detailed description agrees closely with my material from the Coastal Plain of Georgia and South Carolina. Farther south, *victa* has been recorded from Madison and Duval counties, in north Florida (Trapido, *loc. cit.*); it ranges thence southward throughout the Florida Peninsula.

Thus the area above the Fall Line and the higher Coastal Plain of western Georgia is inhabited by *S. dekayi wrightorum;* in the Coastal Plain of eastern Georgia and adjacent South Carolina, *wrightorum* is replaced by a form that agrees with *victa* in coloration, pattern, and body form. These two types are somewhat segregated both

[1] Trapido gives the locality as "Charleston County," a *lapsus*.

geographically and ecologically, but intermediate populations are produced in many areas. The *victa*-like form usually displays 17 scale rows in the upper Coastal Plain, but, farther south, specimens with only 15 scale rows become increasingly common; at about the level of the Georgia-Florida border nearly all specimens have 15 rows. These snakes with 15 scale rows represent the current concept of *victa*.

Other features of *victa*, such as the relatively high number of ventrals and subcaudals, the ventral markings, and the light nuchal collar, are of little diagnostic value, since Georgia *wrightorum* and Florida *victa* overlap widely in these characters. In this connection, Carr states: "Variation . . . in *victa* . . . embraced all the characters of *dekayi* except the two additional scale-rows of the latter" (1940, Univ. Fla. Pub. 3, 1: 91). Trapido's photographs show that some specimens of *victa* closely resemble certain specimens of *dekayi* in appearance (*op. cit.*: 40).

The DeKay's snakes of the East Georgia Coastal Plain approach *victa* not only in form and coloration, but also in habits and habitat (see Neill, 1948, Herpetologica, 4: 163).

New-born specimens of Georgia *wrightorum* are scarcely distinguishable from those of Florida *victa*, both being nearly black above and gray below, with a conspicuous white neck-ring.

Trapido was hesitant in the assumption that *victa* was derived from *a dekayi* stock. He considered *dekayi* to have been a derivative of *S. storerioides*, a form with 15 scale rows, and was "reluctant to assume that in the course of evolution the scale rows would be increased and subsequently again reduced" (*op. cit.*: 44). However, he states elsewhere that *dekayi* may have been derived from a pre-*storerioides* stock with 17 scale rows (*op. cit.*: 81). In any event, apparent reversal of phylogenetic trends is not unusual in snakes. Trapido further expresses the opinion that *victa* was evolved during the insulation of a portion of Florida, from a population of *dekayi* thus isolated (*op. cit.*: 44). While this is possible, it seems unnecessary to invoke such an elaborate hypothesis; *victa* could well be a lineal descendant of *wrightorum*.

From the preceding discussion it is evident that the Florida brown snake is properly to be called *Storeria dekayi victa*, since it intergrades with *S. d. wrightorum* in the Coastal Plain of eastern Georgia.—Wilfred T. Neill, *Research Division, Ross Allen's Reptile Institute, Silver Springs, Florida.*

EUMECES FASCIATUS IN FLORIDA.—Since Taylor pointed out that the blue-tailed skinks of the southeastern United States were a composite of three species, there has been considerable doubt as to whether *Eumeces fasciatus*, the widespread northern form, reached Florida. Taylor lists specimens of *E. fasciatus* from Marion County and "Vanderburg County," Florida (1935, Kans. Univ. Sci. Bull., 36: 207). Goin has quite properly questioned the Marion County record (1940, Copeia: 52); extensive collecting by many herpetologists over a period of years has produced no *E. fasciatus* from that area. In addition, there is no Vanderburg County in Florida, and this record may accordingly be discarded.

On September 20, 1949, the authors collected 2 specimens of *Eumeces fasciatus* in woods bordering the Chipola River about 4 miles north of Scott's Ferry, Calhoun County, Florida. The occurrence of the form in this area is not particularly surprising, for a number of amphibians and reptiles extend their range southward into Florida along the Apalachicola drainage. In both specimens, the upper labials number 7, the last being separated from the auricular opening by a pair of subequal postlabials. The primary temporal is large, and the median subcaudals are distinctly widened. The dorsolateral light line follows the third and fourth scale rows, and there is no evidence of a sublateral light line. The specimens are typical of *E. fasciatus*, which henceforth may be included in the Florida checklist.—Wilfred T. Neill and E. Ross Allen, *The Reptile Institute, Silver Springs, Florida.*

TWO SPECIMENS OF THE SNAKE *FICIMIA STRECKERI* FROM TEXAS.—Returning from a collecting trip during the afternoon of May 30, 1949, I found DOR 2 specimens of the snake *Ficimia streckeri* Taylor, a female and a male. These were taken 10 and 11 miles, respectively, west of San Diego, Duval County, Texas. They are Nos. 130 and 131 in my personal collection. This represents a range extension for this form approximately 100 miles northeast of the present northernmost record, Rio Grande City, Starr County, the type locality.

The male specimen is so much flattened that nothing but the length, scale, ventral, and subcaudal counts can be accurately determined. The female, however, is bruised in only two places, and otherwise is a perfect specimen. The female specimen has 135, the male 132 ventrals. These are extremely low counts for *streckeri*. The 6 other specimens known to me vary from a low of 143 (Edinburg, Texas), to a high of 150 (Nuevo Leon, Mexico). Other scale counts seem to be typical of the species, the male and female respectively with 28 and 35 caudals, 18–17–16, and 19–17–17 scale rows, and no internasals. The female has 7–7 supralabials, 8–9 infralabials, and one preocular as well as postocular. Both have a divided anal.

The ground color of both snakes is ashy brown-grey, with many minute black punctations on the posterior margins of the scales; the dorsal spots are brownish-black. Both exhibit a paper white venter; on the female, the white continues to the second lateral scale row, whereas on the male it reaches only to the lower half of the first scale row. The heads of both are darker than the ground color. In pattern, both are unique among Texas specimens. In the male the dorsal bands are broken into a series of 51 very irregular, small, dark spots, spaced 2 or 3 scale lengths apart, with 58 in the female.

Hobart M. Smith (1944, Zool. Series, Field Mus. Nat. Hist., 29: 135–152) mentions a tendency toward spotting in specimens from the Mexican states of Hidalgo and Veracruz, giving this as a basis for putting *streckeri* in the *olivacea* group. Since then, however, Dr. E. H. Taylor has studied the matter further, and finds that there is no intergradation where the ranges of the two species overlap. Dr. Smith (*in litt.*) agrees to retaining *streckeri* as a full species pending further study.

The present specimens show that spotting is not entirely restricted to the southern population, but also occurs in the northern. The blank area between San Diego and Rio Grande City offers a fertile field for the collector, and will, in time, undoubtedly clear up this mystery of the banded and spotted forms.—RALPH W. AXTELL, *Texas College of Arts and Industries, Kingsville, Texas.*

REVIEWS AND COMMENTS

SNAKES.—By Herbert S. Zim. William Morrow and Co., New York, 1949: 1–62, illus. $2.00.—Mr. Zim has produced an admirable little book especially suitable for children by reason of its wealth of illustration. This includes clever cartooning with effective drawings that tell a story or illustrate a particular point. The illustrations are pleasingly carried across each opened pair of pages. There are very few errors, and these are quite outweighed by the excellent material. The mud-snake is labeled rainbow snake, and the absence of snakes from New Zealand is missed, while their much less remarkable absence from Ireland is stressed. In general, full of excellent information and an excellent gift for any child that exhibits an interest in natural history.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago 5, Illinois.*

THE SEA FISHES OF SOUTHERN AFRICA. By J. L. B. Smith. [Capetown] South Africa: Central News Agency, Ltd., 1949: i-xvi, 1–550, 519 figs., 105 pls. (104 colored), 32-page distribution chart. 52s/6d.—"How was it possible" is the thought that keeps running through the peruser's mind. How could so many species—1275 are recognized—be found in a relatively small area of the oceans? How could one man, who until recently followed ichthyology only as an avocation, give them all critical attention and identification. How could so many excellent pictures have been prepared (of the 1245 illustrations combined in the 519 figures and 105 plates, 1100 are indicated as original)? How could the account of 1275 species be brought within the bindings of a single volume? How was it possible to implement the herculean task by final publication? How was the sale price held down to 52 shillings, 6 pence (at present exchange rate, approximately $7.50)? It is small wonder that the first printing of 3,000 copies was promptly exhausted. The relatively few American ichthyologists who have obtained copies of the first run were surely fortunate. Others who are interested in fishes and in fine books will eagerly look forward to the prospected early reprinting with the hope that the new run will suffer no great loss in the quality of the illustrations and no marked increase in the price.

After detailing how the project was initiated and supported, the author succinctly discusses the zones of the sea and their fishes and the South African fish fauna. He shows how the speciose nature of the fauna is attributable primarily to the southwestward extension of the enormous Indo-Pacific fauna and, secondarily, to a rich and, I think, underemphasized endemic element. The 28 South African viviparous species of Clinidae, all restricted to the region and mostly intertidal, comprise the largest and most notable endemic element. The terse explanation of tides that follows is interesting, but the explanation of the round-the-world progression of the tides is based on rather old and still inadequate data, especially for the Pacific. Brief treatment is given to the effects of fishing, scientific nomenclature and methods of classification, ancestry of fishes, dangers of the shore, ichthyology in South Africa, anatomy and physiology of fishes, and preservation of specimens. The sections on Chondrichthyes and on Neopterygii are preceded by discussions of structures and terms used in taxonomy.

It is made clear that the volume was prepared primarily for residents of southern Africa, who wish to identify the fishes they catch, to become acquainted with the fish fauna of their country, and to learn some basic facts in the fascinating science of ichthyology. Toward these ends, in particular, it is most admirably adapted.

Though the book was not prepared for technical ichthyologists or for residents of other regions, it will be very widely used. It will be the first book opened when a fish from South Africa is being examined. The vast accumulation of figures will prove very helpful, not only to the casual student but also to the accomplished ichthyologist, in first, approximate identifications of fishes from many regions. Any novice or any master who peruses the hundreds of figures will amplify his familiarity with marine fishes in general. The book is in effect an excellent introduction to marine ichthyology, for the fauna of southern Africa, north to the tropical Mozambique Channel, is broadly representative of marine fish life from Subantarctic to tropical regions, includes representatives of most pantemperate and other antitropical groups, and covers a large proportion of the pelagic and bathybial types. Unrepresented are few groups other than those characteristic of the North Pacific fauna and its satellite faunas of the Arctic and the North Atlantic, for which other treatises are available.

All who are in any way interested in the study of fishes will feel a deep debt of gratitude to J. L. B. Smith, not only for this major accomplishment, but also for a long series of technical studies, which constitute a notable contribution to ichthyology. His sensational discovery of the living coelacanth crossopterygian, *Latimeria chalumnae*, and his thorough description of this living fossil, overshadow but do not obscure his many other critical contributions. Though we may long for more definitive keys and for fuller descriptions (which, of course, could not have been squeezed into one volume and would have distracted the layman), and though we may argue over many details of taxonomic judgment, particularly in the identification of South African forms with European and with Japanese species, we can all unite, enthusiastically, in saying to the author and to his artists and other associates, 'Well done," and "Thank you very much."—CARL L. HUBBS, *Scripps Institution of Oceanography (University of California), La Jolla, Calif.*

VIE ET MOEURS DES POISSONS DES PLUS HAUTS LACS DE MONTAGNE AUX GRANDES PROFONDEURS DE L'OCEAN. By Ed. Le Danois. Bibliothéque Scientifique, Payot, Paris, 1949: pp. 1–335, figs. 1–85. 960 Fr.—The author has brought together a considerable amount of concise data on the life, habits and ecological associations of the fishes of the world. Compressed into ten illuminating chapters, treatment is given of all known major groups, not in systematic sequence, but in accordance with their habitat and geographical distribution.

Beginning with a historical discussion of the probable ancestors of fossil and present-day fishes and concluding with a resumé and a brief extract from a voyage of the frigate *l'Oceanide* to Jamaica in 1780 describing the marine animals encountered, Dr. Le Danois divides the intervening chapters as follows: shore fishes; anadromous fishes; fresh water fishes; fishes of the neritic zone; fishes of the continental shelf; pelagic and migratory fishes; fishes of the great depths; and catadromous fishes.

The student should find this treatise indispensable, for it brings together a vast amount of knowledge concerning the life histories and associations of not only the more important types of fishes, but of the lesser known as well. The author presents much that is new, as for example an account with illustrations of the copulation of two species of skates, *Raja batis* and *R. asterias*. In the entire array of literature to date extremely little has heretofore been published on the breeding habits of the Batoidei in spite of their many species and global distribution.

The somewhat singular illustrations, drawn by the author, are pleasing and instructive and reflect careful study, especially those of the habitat groups. All in all Dr. Le Danois has made a worthy contribution to ichthyological literature.—WILLIAM C. SCHROEDER, *Museum of Comparative Zoology, Harvard College, Cambridge, Mass.*

FORTSCHRITTLICHE KARPFENTEICHWIRTSCHAFT (Progressive Carp Pond Culture). By Wilhelm Wunder. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart; 1949: 385 pp., 219 illus. 40 DM.—Fish culturists and students of aquatic ecology who have only a fair reading knowledge of German should assign this lucid and simply written book on carp culture to their "must" reference book list. It has been written for the practical culturist and a conscientious effort has been made to explain scientific information in lay language.

Professor Wunder was director of the Co-operative Pond Culture Experimental Research Center of Silesia, Germany. In addition he was director of the Experimental Station for Fish Pond Culture at the University of Breslau. Over the past 20 years he has published, with his students, many significant papers dealing with the applied as well as technical aspects of carp raising. This book not only reviews the literature but points up the main problems and their treatment according to the most modern view. Also summarized are his published and unpublished works during the past 20 years of research in eastern Germany, Poland and Czechoslovakia. At the close of World War II Poland took over Silesia and with it the University of Breslau. Professor Wunder was relieved of his position, and has been expelled in western Germany until only recently when he was appointed professor of zoology at the University of Erlangen. Since 1946, then, he has spent most of his time in preparing the materials for this book; it reflects careful and thoughtful preparation. Abundant evidence is assembled in this book to prove conclusively that adult carp in European ponds, contrary to the popular view, feed chiefly on zooplankton (75 per cent, carp of age groups III-IV); littoral and bottom animals make up the balance. In carp of age groups O-I the per cent of plankton isn't nearly so imposing, littoral forms making up a greater per cent of food than in older fish. These data are summarized from analyses of over 600 stomachs in which all specimens have been identified and converted to original weights. The charts are complete for feeding habits at all seasons. Wunder has several tables giving the live weight of all of the important plankton organisms, littoral and bottom forms, making it possible to convert the weight of a partially digested organism in the stomach to its original weight. In addition to an extremely thorough analysis of natural foods there are also examples of the value and utilization of the artificial foods and their role in enhancing growth. Methods are appraised for accentuating growth of the natural foods with such measures as rotation drying of the pond bottoms, cultivation of the pond soil. Attention to dry fallow has proved its worth as a production-enhancing

method. Eradication of the "hard" aquatic plants and some "soft" aquatic plants (some species of large aquatic plants are considered advantageous in carp ponds) was recommended. Artificial fertilization is treated at length. A critique of the various types and quantities of fertilizers is given for different soil and water types. Fertilization techniques are directed toward maintenance of high blue-green algae production. Over 100 pages are devoted to the section giving a comprehensive discussion of examples of carp diseases; these are abundantly and clearly illustrated.

TABLE I

CASE HISTORIES OF TWO LARGE FERTILIZED SILESIAN PONDS

Year	Number of carp stocked (age group II, av. wt. 500 g.)	Total initial weight, in kg.	Yield per Hektar, in kg.	Amount of artificial food added, in kg.
1926	140	—	130	110
1932	1050	—	450	60
1937	300	—	250	450

TABLE II

Year	Number of carp stocked (age group II, av. wt. 500 g.)	Total initial weight, in kg.	Yield per Hektar, in kg.
1928	250	220	320
1929	210	120	220
1930	270	180	300
1931	320	130	350
1932	280	220	340
1933	280	120	370
1934	285	110	420
1935	340	100	470
1936	480	160	700
1937	590	170	470
1938	390	110	430
1939	510	140	680
1940	430	150	600
1941	620	140	460

A short but interesting section discusses the influence of environment and feeding on body form of carp. In addition, other aspects of growth are stressed in their relation to culturists' problems.

Of prime importance and interest is a section on inheritance. In keeping with the modern trend in biology this is stressed and exemplified in commendable fashion and points up the advantages the modern culturist might attain from more attention to genetical aspects of fish culture.

The subject of effect of crowding on production is only briefly sketched. Owing to the importance of the effect of the space factor (crowding) on fish growth and its bearing on yield the ecologists would like to have seen more data like those in the accompanying tables which demonstrate the upper limits of yield and maximum fish size attained with varying intensities of stocking. Unfortunately no figures were included for average weights except for a comment that the average size of the fish at time of harvest was very much smaller when larger numbers of fish were stocked, e.g., years 1937 to 1941. With such abundant data available it would have been interesting to the student of fish populations to have had sufficient records of statistical treatment.—ARTHUR D. HASLER, *Department of Zoology, University of Wisconsin, Madison, Wisconsin.*

FIELD BOOK OF NATURAL HISTORY. By E. Laurence Palmer, Whittlesey House, McGraw-Hill Book Company, Inc., New York, N. Y. 1949: pp. x + 664, many illustrations. $7.00.—This is an encyclopedia of natural history, of plants, animals, minerals, the earth and heavenly bodies. The short section on astronomy includes sky charts, and a directory of the principal stars and constellations, their distances, magnitudes and periods. In another short section the principal types of minerals are illustrated and their physical features described. The book is devoted principally to the living world, about half to plants, half to animals. Proceeding systematically up through first the plant kingdom, then the animal, "type" species were selected for consideration, usually one or occasionally up to several species per family. Cultivated plants and domestic animals are included. The species are illustrated as aides in identification. The classification of each form is given from Division or Phylum through Class, Order, Family and scientific and common name. The write-up on each species includes a description of characters of special interest in identification, notes on geographical distribution and habitat, natural history notes on food, growth, reproduction, etc., comments on economic importance to man, and other subjects.

Throughout most of the book, the text is set up in three columns per page, and each column is devoted to a single type—the total thus being about 1800 species of organisms. There is an index to both common and scientific names.

The illustrations are of professional caliber, and good. The text is concise, authoritative and informative. The author acknowledges much assistance from numerous artists on the illustrations, and from an impressive list of specialists (at Cornell University) in criticizing the several sections of the work.

It is not intended to be a field book for recognition of species, since only a small minority of all species of organisms are included. But there is a wealth of reliable information on all "types" of plants and animals, including a great majority of the species that are best known to man.—GERALD P. COOPER, *Univ. Museums Annex, Ann Arbor, Mich.*

NATURAL HISTORY OF MARINE ANIMALS. By G. E. MacGinitie and Nettie MacGinitie. McGraw-Hill Book Company, Inc., New York, N. Y. 1949: pp. xii + 473. Illustrated. $6.00.—The book deals with marine animals, principally those of the continental shelf and tidal zones. Geographically it is of general interest, whereas the authors, in citing examples of biological principles, have drawn heavily on their extensive experience along the California coast. Perhaps the best keynote to the nature of the book is contained in its dedication "To those people who, after watching the activities of some of our marine animals, have said, 'You ought to write all this down.'" The MacGinities have "written down" a great deal of the results of careful observations on marine invertebrates in natural habitats and in aquariums.

The first few chapters deal with general considerations of ecology of the marine shore zone and its fauna—with food, physical factors of environment, classification of animals, biological processes, and other general subjects. There is an interesting discussion of the roles of variation and succession in animal evolution, stressing the points that instinctive behaviors have an important part in evolution as well as do structures and physiological processes, and that ecological successions are generally complex and, especially, unpredictable.

Each of the major phyla of marine animals is then treated in a separate chapter, in a style that is quite typical of texts in college zoology which are mostly descriptive morphology and natural history. Principal types are discussed as to structure, habitat, feeding, reproduction and other things of special interest. The photographs and drawings are good, but not so numerous as in the average text. No doubt the book will be most useful to marine biologists on the Pacific coast, because that is the locale of a majority of the illustrations and the authors' observations on natural history. But marine biologists generally should find it interesting reading and a useful reference.

In the field of vertebrate zoology a few statements were noted which seem open to some doubt or in need of correction: "cyclostomes are mainly scavengers," the minimum size of adult lampreys given as 18 inches, and hagfishes are "the only vertebrate animals that are functionally hermaphroditic." The section of the book on marine vertebrates is quite brief, in proportion to other sections.—GERALD P. COOPER, *University Museums Annex, Ann Arbor, Michigan.*

FRESH WATER FISHING—BAIT AND FLY CASTING, SPINNING, LURES AND EQUIPMENT. By Arthur H. Carhart. A. S. Barnes and Company, New York, 1949: xiv + 237, 18 col. pls., num. figs. $5.00.—As the name implies this book was written for the angler, not the ichthyologist. The latter may shudder at some of the statements made about fish and their environment (when will otherwise competent outdoor writers learn to ask their scientist friends to criticize their natural history statements?) but the angler will certainly enjoy this book. The approach and treatment of a subject so much written about in the past are novel, entertaining and instructive. Carhart stresses *why* one should fish with certain lures in certain ways if he is to be successful.

A brief history of angling with artificial lures opens the book. Discussion of why various methods should be employed under different conditions follows. In these chapters game fish are classified as "cold-water," "cool-water" and "warm-water" fishes. The trouts, salmons, graylings and whitefish are properly placed in the first class. However, most biologists would feel that the smallmouth black bass and the pike belong in the "cool-water" group along with the yellow perch, sand pike and walleye instead of in the "warm-water" category. Natural distribution records would support this contention. Proceeding from this rough classification the author points out that the temperature preferences of these fish largely dictate the tackle to be used and the methods of fishing.

Many writers, including scientists, have tried to simplify the process of identifying fishes. If the author, an outstanding conservationist and outdoor writer, has not completely succeeded in the chapter devoted to this subject no ichthyologist will be surprised and the author should not be too disappointed. Here again some technical help would have improved the value of the book.

Discussion of tackle and how to use it in catching different kinds of fish makes up the bulk of the book and the author draws on his extensive fishing experience and is on safe ground. Starting with the hook and proceeding to leader, line, reel and rod the history of each of these parts of the equipment and the best combination for each kind of fishing follow in orderly sequence. Woven into what might otherwise be rather dry reading are many personal experiences which illustrate the arguments for tackle or methods and make the book more digestible. The sketches by Hamilton Greene add much to the interest and to the clarity of the discussions.

The final chapter—"Tomorrow's Fishing" stresses maintenance and restoration of the environment as the key to improved angling. Soil conservation, control of pollution, proper consideration of fish needs in planning construction of impoundments and their operation are the methods recommended by the author. The book closes with a plea for the fifteen million people who fish to present a united front against the forces working for destruction of the environment and to pull together with all agencies seeking more intelligent use of our natural resources.—ALBERT S. HAZZARD, *Institute for Fisheries Research, Ann Arbor, Michigan.*

ENCYCLOPEDIA OF WATER LIFE, nos. 1–3, 1949. Editors: J. J. Hoedeman, Dr. J. C. M. de Jong. Illustrator: M. van Boordt. Collaborators: Dr. L. F. de Beaufort; W. J. M. Dentz; Dr. H. Engel; Ingvar Kristensen; Dr. F. P. Koumans; Dr. J. M. Lodewijks; Dr. J. R. Müller. Published by De Regenboog, Amsterdam, and Brown Brothers Harriman and Co., New York City. Complete set, $21.00 in advance.—This encyclopedia of water life is a revised English version of the original Dutch work "Encyclopaedie voor de Aquariumhouder," 1947. The whole work is divided into 20 chapters, some of which are on general biology, botany and zoology; others deal with the systematics of Protozoa, Vermes, Arthropoda, Tunicata, Pisces, Amphibia and Reptilia. There are 6 chapters on aquaria, fresh-, brackish- and saltwater. The first 3 parts that I have seen are well written, have numerous illustrations, including several beautiful color plates. This encyclopedia is written for the aquarist and any person interested in aquatic life.—LEONARD P. SCHULTZ, *United States National Museum, Washington 25, D.C.*

FIELD GUIDE TO THE LIZARDS AND SNAKES OF WISCONSIN.—By W. E. Dickinson. Milwaukee Public Museum Pop. Sci. Handb. Ser. 2, 1949: 1–72. 75c.—It seems extraordinary to find so inadequate a treatment of a group so much studied as are the lizards and snakes, published in 1949. Mr. Dickinson's little work provides excellent illustrations of the viability of error, for the records of the "pine lizard," black snake, Say's king snake, and diamond-back water snake, are only too clearly based on mistakes in the early literature. In the black snake record, as in his notes on the red-sided garter snake and the ribbon snake, Mr. Dickinson fails to understand what is meant by subspecies, or, indeed, what is meant by species. The identification of every specimen of the common garter snake that has red skin between the scales as *Thamnophis sirtalis parietalis* entirely misses the populational concept of species and the geographic limitations of the meaning of subspecies.

That the expense of color plates should have been wasted by what is evidently inferior reproduction of much better originals (the plates being uniformly much too green), is nothing short of calamitous in this day of prohibitive expense of color. Both registry and color values could have been improved by critical examination of the proofs, and many of the figures are much too small to be useful. Mr. Dickinson would have been well advised to enlist the aid of some of the eager young herpetologists of the Middle West, for whom the attempt to make an account of the snakes and lizards of Wisconsin meaningful on one hand and useful on the other would have been a challenge.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago, Illinois.*

EDITORIAL NOTES AND NEWS

News Notes

KARL P. SCHMIDT, herpetological editor of COPEIA, is spending three months in Germany as a member of the University of Chicago-University of Frankfort exchange of faculty. He will work mainly in the Senckenburg Museum and will also visit the museums in Paris and London, returning about August 1.

In the greatly expanding program of fisheries research on the Great Lakes by the United States Fish and Wildlife Service, new additions to the staff include: DR. PAUL H. ESCHMEYER (lake trout studies), MISS LOUELLA E. CABLE (age and growth studies) transferred from College Park, Maryland, LEO F. ERKKILA (commercial fisheries) transferred from Antioch, California, HOWARD A. LOEB (lamprey studies) transferred from Billings, Montana, BERNARD R. SMITH (lamprey studies) transferred from Antioch, California, ALBERT E. HALL and ALBERTON L. MCLAIN (lamprey studies), and WILLIS S. GLIDDEN (fishery statistics). The necessary additional office space for this expanded program has been provided by the University of Michigan at 1220 East Washington Street, Ann Arbor, Michigan, the new address for those listed above.

Back numbers of COPEIA have recently been donated to the Society by ROBERT CARNEIRO, GEORGE W. DANFORTH, MRS. L. E. GRIFFIN, and WILLIAM H. STICKLE. These numbers will be used to complete sets for sale to libraries.

Doctoral Work in Progress

DOCTORAL projects in Fisheries Biology now being carried on at Iowa State College, Ames, are reported by DR. KENNETH D. CARLANDER as: WILLIAM TATE, life history and management of smallmouth black bass, *Micropterus dolomieu,* in the smaller streams of eastern Iowa; ROBERT MOORMAN, on the utilization of farm ponds for fishing; GEORGE SPRUGEL, on the growth of fishes in relation to population density, particularly as the density is changed by winter kill; ARDEN GAUFIN, on an ecological and productivity study of the Provo River, Utah.

At Rutgers University Department of Zoology, New Brunswick, New Jersey, ELIAS COHEN is studying serological relationships in reptiles and amphibians—particularly between the families of snakes and the intraspecific relationships in *Rana.* He is interested in procuring the blood sera of any reptiles and amphibians, especially of the snake families Hydrophidae, Viperidae, Aniliidae, Leptotyphlopidae, Typhlopidae, Anomolepidae, Xenopeltidae, and Uropeltidae. Containers and directions for preserving will be sent to anyone interested. Mr. Cohen is also engaged in a genetic analysis of the color dimorphism in *Plethodon cinereus.*

DR. W. FRANK BLAIR writes that the following problems in herpetology are being carried on at the University of Texas: A. G. FLURY, on biological relations and problems of interspecific competition in several species of lizards in the Glass Mountains, Texas; D. L. JAMESON, on the biology of *Syrrhophus* populations in Texas; W A. THORNTON, on isolating mechanisms in toad (*Bufo*) populations in central Texas. All of these students may be reached through the Department of Zoology, University of Texas, Austin 12.

Current graduate work on the cold-blooded vertebrates in progress at the Department of Biology of the University of Florida, as reported by DR. ARNOLD GROBMAN, includes:

Fish—WILLIAM M. MCLANE, Distribution of the fishes of the St. Johns River drainage; *Ameiurus natalis* in subterranean waters of Florida. W. DEAN MOODY, A contribution to the natural history of the spotted trout, *Cynocion nebulosus.* GEORGE K. REID, JR., Bayfishes of the Cedar Keys area. R. KIRK STRAWN, An ecological study of the seahorses of the Cedar Keys area.

Amphibians—JOHN D. DECKER, The chrosome morphology of the Sirenidae. JAMES C. KNEPTON, A study of the use of native frogs in the diagnosis of early pregnancy.

Reptiles—EDWIN H. MCCONKEY, A systematic study of the genus *Ophisaurus;* Studies on the *Eumeces egregius-onocrepis* complex.

Requests

DR. EDWARD M. NELSON (Department of Anatomy, Stritch School of Medicine, Loyola University, 706 South Wolcott, Chicago 12, Illinois) writes that he is doing research into the anatomy and evolution of the catostomid fishes and is especially interested in *Cycleptus elongatus.* Anyone having specific knowledge about the natural history, development or distribution of this fish is urged to communicate with Dr. Nelson.

J. L. B. SMITH, whose magnificent volume on "The sea fishes of southern Africa" is reviewed in this issue, announces that he is now considering plans for a treatise on the fish fauna of the entire eastern coast of Africa. He would appreciate the assistance of American colleagues in obtaining old and new literature that would bear on this subject.

A recent fire at Southwestern College, Winfield, Kansas, destroyed the personal library of DR. THEODORE H. EATON, JR. Your spare reprints will be greatly appreciated by Dr. Eaton.

"Basilisk"

DR. F. MAEDER has announced the establishment of a new enterprise in Switzerland, under the name "Basilisk," for the purchase and sale of live animals, especially reptiles. "Basilisk" will offer a large selection of live reptiles, of world-wide distribution. A catalog giving much general information on terraria, methods of keeping reptiles and caring for sick animals, together with a full description of each listed species and detailed directions for feeding and care, will be furnished on request. The address is: "Basilisk," Blauensteinerstr. 10, Basle, Switzerland.

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